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SVIC NOTES

"Information conserves other resources through better decisions."
-- Walter M. Carlson, IBM Corporation

Mr. Carlson is a former Director of Technical Information for the Department of Defense (DoD). The quote is from an address to a DoD Technical Information Conference last March. His presentation was inspiring and quite to the point. We must make effective use of information for productivity or performance improvements of the organization. To do this, available information resources should be used whenever possible. The cost of ready access to technical information is really very small when compared to the savings that can be realized in various stages of research and development programs. Improved performance, time saved by engineers and scientists, and money saved by not duplicating the work of others are the results of knowing about new developments applicable to an R&D program. Precise savings in these areas are difficult to measure. Mr. Carlson suggests that we measure the cost of not knowing. If you don't know about a new material that meets your requirements, you may proceed with an unnecessary development program. If you don't know about a new technique that reduces testing time, you may spend more on tests than you should. The examples are endless.

In the spirit of Mr. Carlson's remarks, we at SVIC continue to provide, as effectively as we can, timely information to the shock and vibration community. This DIGEST, our monographs and special publications, and our search and analysis service are available to meet your special needs. Our symposia and bulletins as a platform and archive for new knowledge, data and know-how in the shock and vibration field seem to get more exciting every year. The 52nd Symposium this month in New Orleans promises to be particularly outstanding. You can examine the program for this meeting in the September issue of the DIGEST.

In connection with the 52nd Shock and Vibration Symposium, I would like to use this space to thank the Technical Program Committee for doing a particularly fine job. Lt. Col. Dwayne Piepenburg of the Defense Nuclear Agency represented the Host. Mr. Don McCutchen of NASA, Johnson Space Center organized some exceptional sessions relating to Space Shuttle. Mr. Charles Fridinger, Naval Surface Weapons Center; Mr. Tommie Dobson, 6585 Test Group, Holloman AFB; and Mr. James Daniel, U.S. Army Missile Command make up the rest of a fine team. Thanks very much fellows.

Finally, I must report that Mrs. Carol Healey has left the SVIC staff. She did an outstanding job and we will miss her. I wish her well in her new job. Mrs. Jessica Hileman is joining SVIC as Carol's replacement. I think those of you who meet her at the symposium will agree that we are lucky to get such a talented lady. Welcome aboard, Jessica.

H.C.P.

EDITORS RATTLE SPACE

CONTINUING EDUCATION

Many forms of continuing education are flourishing in the technical community today – from meetings, short courses, and seminars to journals, magazines, and books. Indeed, the DIGEST itself is a form of continuing education.

The presentation and publication of formal papers at such technical meetings as the Shock and Vibration Symposia and the ASME Vibrations Conference have served as mechanisms for the exchange of technical information for many years. These meetings also provide an opportunity for engineers to informally exchange ideas and information. A calendar of technical meetings is provided in the DIGEST.

Technical seminars give engineers the opportunity to obtain updated information in a condensed form. Usually the seminar represents a distillation of recently published technology. Technical experts intimately involved in engineering research and practice conduct the sessions.

Short courses provide organized training in specific areas of technology. These courses usually follow textbook-like notes and can condense a college semester course into a week or two. Short courses and seminars are listed in the DIGEST short courses section.

Journals, magazines, and books are still the major source for continuing education in engineering. The DIGEST abstract section presents objective synopses of the material contained in the literature. The literature and book review sections are intended to be subjective reports of technical material.

It is fortunate that such training is available in today's complex technical world, for more and more individuals are finding that continuing education is necessary in their jobs. And the formal training programs available at the college level do not provide the training needed today.

It is the goal of the DIGEST to keep its subscribers informed on opportunities for continuing education as well as the available literature.

R.L.E.

RECENT PROGRESS IN THE DYNAMIC PLASTIC BEHAVIOR OF STRUCTURES, PART III

N. Jones*

Abstract. *This article surveys the literature on the dynamic plastic response of structures published since 1978. The review focuses on the behavior of such simple structural components as beams, plates, and shells subjected to large dynamic loads that cause extensive plastic flow of the material.*

Interest in the dynamic plastic response of structures has continued to grow at a rapid pace since 1978 [1, 2]. A general introduction to this subject has been published [3], and a wide range of applications has been given [1-3]. Additional developments have been reviewed [4-12].

The influences of finite-displacements and material strain-rate sensitivity on the dynamic plastic response of structures have been described [3], as have the behavior of ideal fiber reinforced beams, higher modal response of beams, influence of transverse shear and rotatory inertia, approximate methods of analysis, the behavior of rapidly heated structures, fluid-structure interaction, dynamic plastic buckling, and numerical studies [1, 2].

This article concentrates on the effects of transverse shear and rotatory inertia and the influence of material elasticity and dynamic plastic buckling. Some comments are made on numerical studies and other recent work.

TRANSVERSE SHEAR AND ROTATORY INERTIA

The importance of transverse shear and rotatory inertia on the dynamic plastic response of beams has been discussed [1, 10, 11]. Theoretical rigid-plastic analyses have been carried out for two beam problems [13]: an infinitely long beam struck by a mass traveling with an initial velocity and a simply-supported beam loaded impulsively. These two problems were reconsidered using the exact Ilyushin-Shapiro yield surface [14]. This method necessitated a relatively straightforward numerical solution.

Transverse shear effects lead to a dramatic reduction in the slopes of the deformed profiles for both beam problems. Moreover, the slope of the deformed profile underneath the striker in the impact problem is sensitive to the actual shape of a yield curve; the maximum transverse displacement is less sensitive. The retention of rotatory inertia in the basic equations leads to further reductions up to 17% and 10% in the slopes and maximum transverse displacements respectively.

Gomes de Oliveira [15] examined the dynamic plastic response of simply-supported and fully-clamped beams that are struck laterally at mid-span by a mass or projectile traveling with an initial velocity. A numerical solution was necessary even though a simplified square yield criterion was employed. Rotatory inertia did not significantly affect the response of the beams examined, but shear effects were very important and led to substantially larger maximum lateral displacements.

It might be shown that the transverse shear force at the simple supports of the impulsively-loaded, rigid, and perfectly plastic circular plate examined by Wang [16] is infinitely large when motion commences. Thus, the influence of transverse shear on the dynamic plastic response of circular plates is of potential importance and has been studied recently [17]. It was assumed in this work that the transverse shear force and circumferential and radial bending moments required for plastic flow were controlled by a simplified yield criterion. This criterion was first used by Sawczuk and Duszek [18] to examine the

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static plastic behavior of circular plates. A simple theoretical procedure, which is exact within the setting of classical plasticity for the selected yield criterion, has been obtained for a simply-supported circular plate subjected to an impulsive velocity V_0 [17]. The theoretical results demonstrate that transverse shear effects are more important for dynamic loads than for static loads. For example, the maximum permanent transverse displacement is two-thirds of the value predicted by a classical bending only theory for a sandwich plate with a diameter-to-thickness ratio of 15 and a 0.5 in. (1.27 cm) thick core with 0.1 in. (0.254 cm) sheets as has been reported [10]. Furthermore, there is a transverse displacement of equal magnitude around the supporting boundary. This displacement is zero in the classical theory of Wang [16] without transverse shear effects.

The role of rotatory inertia (I) on the dynamic plastic response of impulsively-loaded simply-supported circular plates has been explored [17]. The inclusion of rotatory inertia in the governing equations and the retention of transverse shear, as well as bending effects in the yield criterion, result in an increase in the permanent transverse shear sliding at the plate supports and a decrease in the maximum final transverse displacement that occurs at the plate center. However, the inclusion of I gives rise to respective changes in these quantities of approximately 11.5% and 14.2% at most. The simpler theoretical analysis [17] with $I = 0$ would therefore probably suffice for most practical purposes.

Rao and Raghavan [19] have developed a finite-element method to investigate the dynamic inelastic response of thick plates. They presented nu-numerical results for simply-supported and fully clamped square plates and included transverse shear effects.

If transverse displacements due to concentrated shear strain become sufficiently large, at a support for example, complete severance can occur [20]. Thus, the transverse displacements due to shear must remain a sufficiently small proportion of the corresponding structural thickness in the various analyses discussed above.

ELASTICITY, STRAIN HARDENING, AND STRAIN RATE SENSITIVITY

This section discusses theoretical and approximate methods of analysis. Forrestal has continued his development of simple methods of analysis for impulsively loaded beams. These methods account for the influence of elastic effects and material strain hardening and strain-rate sensitivity when required. Forrestal and Sagartz [21] used typical analytical procedures to obtain the elastic response of a beam subjected to an impulsive velocity that is distributed with a half-sine shape across a simply-supported span. This theoretical analysis remains rigorously correct until the maximum stress at the mid-span reaches the associated dynamic yield stress. However, it is assumed for subsequent motion that a beam retains a sinusoidal shape even when plastic deformation occurs. Thus, a fairly straightforward theoretical analysis with linear strain hardening will lead to an expression for the maximum transverse deflection.

If the material is strain-rate sensitive as well, the dynamic yield stress is calculated at the appropriate strain rate predicted by the elastic analysis when yield is first reached. Perrone's [22] assumption is used, and the plastic flow stress is taken as strain-rate insensitive with little sacrifice in accuracy. Forrestal and Sagartz [21] found that this relatively simple theoretical procedure gives excellent agreement with experiments they conducted on beams made from 304 stainless steel. Such steel is used in the nuclear industry.

If only the influence of material strain-rate sensitivity and geometry changes are important, a simple procedure [10] can be used for beams. In the particular case of an impulsive loading distributed uniformly on a fully-clamped beam, the dynamic yield factor and the maximum permanent transverse displacement are predicted in [10]. This approximate method provides excellent agreement with experimental tests [10]. The theoretical method [23] can also be used for a wide range of dynamically loaded beams and plates when geometry changes dominate the response provided material elasticity, strain hardening, and strain-rate sensitivity can be neglected.

Kaliszky [24] developed a kinematic formulation to describe the behavior of dynamically loaded rigid plastic structures. This formulation can be used when changes in geometry and strain-rate sensitivity are important. The approximate predictions show encouraging agreement with more exact theoretical results.

Symonds and co-workers have continued to develop approximate theoretical methods for material elasticity, strain hardening, and strain-rate sensitivity as well as changes in geometry. Symonds and Raphanel [25] used a mode approximation procedure to predict the permanent deflections of the impulsively loaded portal frames tested by Bodner and Symonds [26]. Symonds [27, 28] also used the same method to study the response of fully-clamped beams.

Symonds has summarized his recent studies [29]. The structural response is postulated to occur in three distinct stages. The first wholly elastic stage is terminated when a global yield condition is satisfied and is followed by a rigid perfectly plastic stage and a final elastic vibration. Thus, elastic and plastic effects are separated, and the response can be treated as either wholly elastic or entirely plastic. If the transverse displacements become large during the plastic stage, they sometimes must be divided into two parts. The first part accounts for flexural effects; the second part recognizes large displacements. The analysis for every stage except the initial and final elastic stages is simplified by using a mode approximation method. The velocity amplitude is determined from the end of the previous stage using the minimum Δ_0 technique of Martin and Symonds [30]. Provision is also made in this approximate procedure for material strain rate sensitivity and for large displacements during the initial elastic phase.

Symonds [31] has suggested an improved criterion for seeking optimal modes in dynamic infinitesimal structural problems. The criterion avoids the difficulty inherent in the procedure of Martin and Symonds [30] when both unstable and stable modes are present. Martin [32] recently discussed how mode shapes might be found in complex and more realistic situations. Lepik [33] examined quasi-modal form solutions that retain several simultaneous modes, again with the limitation of infinitesimal displacements. Kim [34], however, explored further the instantaneous mode method for large deflection problems. He used a minimization technique and obtained encouraging agreement with experimental results on impulsively loaded beams [35]. However, a theoretical method [23] gives a simple equation for the permanent deflections of beams; more favorable agreement with corresponding experimental results has been obtained [10]. Moreover, another simple equation [3, 10] also predicts excellent agreement with test results on strain-rate insensitive rectangular plates loaded dynamically; the mode approximation method therefore requires considerable further development before it can become a design tool. Its advantages will be that it can be used for various secondary effects but not without some cost in increased complexity.

In discussing mode form solutions, it should be mentioned that Symonds and Wierzbicki [36] have examined the response of impulsively loaded circular plates with large deflections by retaining only membrane forces in a mode solution. Lepik and Mroz [37] investigated the optimal design of an impulsively loaded stepped beam using asymmetric mode forms.

Perrone and Bhadra [38] examined a simple beam model in an attempt to develop and examine the accuracy of approximate methods of analysis. The beam is idealized as a string with membrane forces; changes in geometry are taken into account but not bending effects. A mass at the mid-span is loaded impulsively; the beam material is idealized as rigid-viscoplastic with linear strain hardening. This problem is sufficiently simple so that an exact solution is possible. The maximum membrane strain rate is attained when approximately one-half the initial kinetic energy has been dissipated. Thus, the maximum strain rate might be quickly estimated in this class of problems and used to obtain the associated strain-rate sensitive flow stress; the stress is then taken as a constant during the entire response. This procedure has been successfully used for some plate problems, but to the writer's knowledge the details have not yet been published.

BEAMS, PLATES, AND SHELLS

Many of the articles cited in the previous sections contain investigations into the dynamic plastic behavior of beams, plates, and shells. The articles considered in this section contain largely theoretical and approximate studies.

Wojno and Wierzbicki [39] developed a perturbation method of analysis for impulsively loaded structures made from materials with viscoplastic characteristics that are idealized as homogeneous viscous [40]. An exponent in the viscoplastic law is identified as a small parameter in the perturbation procedure. Reasonable agreement when neglecting flexural effects was obtained with experimental results on impulsively loaded beams [35].

Bak [41-43] examined the dynamic plastic response of rectangular plates, but, because the influence of changes in geometry were not retained in the governing equations, reasonable agreement with corresponding experimental results [44] was found only at smaller permanent deflections. The loading capacity of a rectangular simply-supported reinforced-concrete plate under shock loading was examined theoretically using plastic methods of analysis [45].

Ghosh and Weber [46] reported a theoretical and experimental investigation into the dynamic response of an axisymmetric rigid-plastic membrane. Good agreement was found between the results except for the variation in final thickness of the lead plates.

The dynamic plastic behavior of a miscellaneous collection of shell problems has been considered [47-52]. An interesting study into the plastic response of a chain of circular rings due to an axial tensile impact has been examined largely from an experimental viewpoint [53].

DYNAMIC PLASTIC BUCKLING

Dynamic plastic buckling has been reviewed briefly [3] and thoroughly [1]. Comments have also been given [10].

An idealized column was studied [54] in an attempt to obtain insight into and clarify the phenomenon of dynamic plastic buckling. The column included a nonlinear spring to model the post-buckling characteristics of real structures; two masses one of which was constrained to move axially and the other laterally; initial geometric imperfections; and elastic linear work hardening springs that idealize elastic, plastic, and material work hardening effects.

If the axial mass is zero, analytical solutions for dynamic elastic, elastic-plastic, and plastic-elastic buckling can be obtained using a phase-plane method. These theoretical results have interesting features. For example, the dynamic step buckling load of a perfect and almost perfect model is larger than the associated static buckling load. The difference is due to the different elastic-plastic deformation histories during the static and dynamic responses. It is of interest that Hartzman [55] observed a similar situation between the dynamic and static buckling pressures of a geometrically perfect elastic-plastic spherical dome. However, the dynamic buckling loads of the idealized model are smaller than the associated static ones when the initial imperfections are sufficiently large. It is also apparent from theoretical results [54] that dynamic buckling of an imperfect model can be elastic even though a perfect model with the same parameters would buckle plastically. The dynamic plastic-elastic buckling load is smaller than the corresponding dynamic elastic buckling load for a given magnitude of initial dimensionless imperfection; the difference between the two buckling loads increases as the strain hardening parameter * decreases.

A numerical solution is required when the influence of the axial and lateral masses is retained in the governing equations [54]. A direct form of dynamic buckling occurs within the range $0 < \omega_1/\omega_0 < 0.5$. * This response is characterized by a high frequency oscillation superposed on a dominant mode that represents a lateral vibration of the idealized column about a deformed state. The period of the dominant mode grows as the vertical load is increased; the dynamic buckling load is reached when the amplitude becomes unbounded. The dynamic buckling loads in this regime are very sensitive to the magnitude of the initial geometric imperfection and are more sensitive to imperfection than those for the corresponding wholly elastic dynamic buckling case.

The character of the response in the region $0.5 < \omega_1/\omega_0 < 1.0$ is different from that described above for $\omega_1/\omega_0 < 0.5$. In this case, high frequency vibrations are superposed on a dominant mode having a very large period. The total duration of the numerical calculations is therefore important. The buckling load was obtained as the smallest load that caused a specified amplitude to be exceeded within the interval $0 < \tau < 100$. ** This type of behavior is similar to the indirect buckling phenomenon studied by Lock [56], who examined a dynamic elastic buckling

** See Reference [54] for definition of parameters*
*** τ is dimensionless time [54]*

problem. The numerical results for the behavior of the idealized model are less sensitive to imperfection for indirect buckling than for direct buckling.

Lee has continued his studies into the dynamic stability of continua. He used his quasi-bifurcation criterion [57] to examine the elastic behavior of a simple four-degrees-of-freedom system [58] and the dynamic inelastic buckling or a rod [59], a column [60], and a spherical shell [61] that had previously been examined [62, 63]. The quasi-bifurcation theory has also been used to examine the dynamic axisymmetric buckling of a buried elastic-plastic pipeline subjected to seismic excitations that produce comparatively high axial stresses [64].

Kao [65] developed a finite-difference method to examine the dynamic elastic-plastic buckling of axisymmetric spherical caps with initial imperfections. Ishizaki and Bathe [66] used a finite-element procedure to investigate the dynamic plastic buckling of a shallow cap, a complete spherical shell, and a cylindrical shell.

The perturbation method of analysis [10] can provide useful theoretical predictions for a certain class of structures. This procedure was employed [67] to examine the dynamic plastic buckling of a stringer-stiffened cylindrical shell subjected to an axial impact. It is more efficient to place stiffeners with rectangular cross sections on the outer shell surface than on the inner surface. Results demonstrate the influence of the second moment of area, eccentricity, cross-sectional area, and number of stiffeners on the dynamic plastic response. Additional results and comments have been published [68].

Experimental tests on the dynamic plastic buckling of aluminium 6061 T6 cylindrical shells subjected to lateral blast pressures have been conducted [69].

The phenomenon of dynamic plastic buckling plays an important role in full-scale light aircraft crashworthiness tests [70-74]. In one case the numerical predictions of a hybrid computer program and two finite-element computer programs were compared with experimental results recorded during vertical impact velocity crash tests [73]. Additional comparisons have been made between the hybrid computer program and experimental results [74].

Crashworthiness tests have been conducted on small-scale aluminium fuselage structures [75]. A finite-element method that employs a lumped mass-stiffness idealization was developed.

The dynamic plastic buckling characteristics of tubes and other components also plays an important role in the energy absorption characteristics of motor vehicle structures [76-79]. Another important current practical area of concern is the design of pipewhip restraint systems that can involve dynamic plastic buckling [80, 81]. Dynamic plastic buckling can also play a part in the design of hazardous material containers [82-84] and modular crash cushions [85, 86].

NUMERICAL STUDIES

Numerical studies have been discussed [2, 3]. Additional studies are mentioned briefly in this section.

Witmer and co-workers have continued their long interest in the dynamic plastic behavior of structures. Pirotin and Witmer [87] used a finite-difference procedure to study the dynamic behavior of shells when they impact rigid barriers. Such behavior is of interest in the protection of nuclear power plants. Progress on the MENTOR finite-difference code has been reported [88] and some applications of the PETROS 4 numerical finite-difference scheme presented [89].

The transient response of beams and rings impacted by fragments [90, 91] is of interest in the design of systems to deflect aircraft turbojet engine rotor fragments away from critical regions. Experimental tests on aluminium panels struck by steel spheres [92] were undertaken in part to provide experimental data as a check of numerical schemes on fragment impact [93]. Rodal and Witmer [94] reported development of their finite-element procedure for dynamic inelastic structural problems involving finite strains.

Other research groups have developed numerical schemes that can be used to study the dynamic plastic behavior of structures. Belytschko and Marchertas presented a nonlinear finite-element method [95] and obtained reasonable agreement with experimental tests on wide beams loaded impulsively [96].

The behavior at the supports could have been captured more accurately with a greater density of finite elements in the vicinity of the supports. The numerical scheme was also used to study the transient response of a hexagonal fuel subassembly.

Finite-element methods for studying the transient response of beams have also been developed [97, 98]; one is a novel mixed formulation [97]. The other [98] compares the method with experimental work on both beams and circular and rectangular plates loaded impulsively. The method predicts good agreement with test results on wide beams [96] and fully-clamped rectangular plates [44] made from aluminium 6061 T6, which is a strain-rate insensitive material. Even better agreement, particularly near the boundaries, would probably have been obtained if more finite elements had been used in the numerical calculations. However, the numerical scheme with material strain-rate sensitive effects gave less favorable agreement with an identical series of tests on wide beams and rectangular plates made from mild steel [44, 96], possibly due to the formulation of strain-rate sensitive effects. Further work is required to clarify the situation.

A finite-element method for describing the axisymmetric behavior of circular plates and shells of revolution has been developed [99] using a stress resultant formulation. The computational effort is thus simplified because yielding occurs simultaneously across the entire cross section. However, Raghavan and Rao [100] demonstrated that a finite-element procedure based on moment curvature relations significantly underestimates the response predicted by a more exact formulation when the duration of the applied load is longer than about half the natural period.

Lukkunaprasit and co-workers [101] simplified the numerical calculations for dynamic inelasticity by using modal coordinates and disregarding possible loading/unloading regions. They obtained encouraging results for the earthquake analysis of multistory shear buildings when only a few lower modes were obtained. However, the method might be less effective for impulsive loading situations requiring the retention of a greater number of higher modes in the numerical calculations.

Numerical predictions of the ICEPEL piping code have been obtained at Argonne National Laboratory for the safety analysis of liquid metal fast breeder reactors [102]. Experimental results were recorded on pipes with large internal pressure pulses propagating along the pipe axis. The agreement between the numerical predictions and experimental results is excellent, particularly in view of the complexity of the problem.

A finite-difference procedure [103] was developed to examine the dynamic elastic-plastic axisymmetric behavior of a fluid-filled unstiffened shell. This numerical scheme was used to investigate the response of a water-filled nuclear containment vessel when the relief valve discharge piping is cleared.

Garnet and Armen [104] used a one-dimensional finite-element method to study the impact of a rod against a deformable barrier – an idealization of a vehicle striking an obstacle. The rebound of a vehicle and its subsequent repeated impact against a barrier are important considerations in crashworthiness studies. The modeling of a deformable barrier as rigid can in some cases lead to smaller maximum stresses in the impacting rod.

Various numerical schemes have been used [105-110] to examine the dynamic plastic behavior of beams and frames. A numerical method developed by Laudiero [108] is capable of handling any load and boundary conditions for ideal fiber-reinforced beams [1]. Incidentally, Shaw and Spencer [111, 112] studied the dynamic plastic response of ideal fiber-reinforced plates.

Stolarski [113] has continued his studies [109] and developed an extremum principle for the dynamic plastic behavior of shells that undergo large displacements. The resulting finite-difference formulation was used to examine the axisymmetric response of a cylindrical shell loaded impulsively over part of the axial length.

Zudans [114] discussed implicit and explicit computational schemes for the dynamic plastic behavior of structures. Oden and Bathe [115] have written a timely and thought-provoking commentary on computational mechanics.

MISCELLANEOUS STUDIES

A great deal of activity on the dynamic plastic behavior of pipelines subjected to various impact loads has been reported recently. The response of piping systems subjected to pressure transients generated during a sodium/water reaction in a failed steam generator of a liquid-metal-cooled breeder reactor was studied [116, 117]. The plastic deformation of a pipeline was taken into account and might indirectly contribute to the formation of transient cavitation in piping systems. The influence of cavitation due to the possible inability of a fluid to adjust to structural motion without reaching its vapor pressure has been studied [118].

Belytschko and Mullen [119] examined the particular case of a circular cylinder striking a quiescent pool of water. This problem is related to slamming and bow damage studies [120, 121]. Such studies might be extended to shells using a theoretical procedure [122].

Palusamy and Manhardt [123] conducted experimental tests on stainless steel pipes subjected to lateral impact loadings. This study was motivated by the necessity for a realistic evaluation of the interaction between pipes and pipewhip restraints during a postulated pipe break in a nuclear power plant. Other experimental work [124] also provides valuable information on the behavior of a pipe that strikes another object after a pipe break. The tests were conducted on pipes that were struck by cylindrical projectiles with conical heads.

The plastic flow stress will be a function of strain rate during a pipewhip in a nuclear reactor for pipelines made from materials that are strain-rate sensitive. Data on the static and dynamic properties of two typical pipeline materials have been published [125]. Other studies have been conducted on the strain-rate sensitive behavior of different materials at various strain rates [126]. However, it should be remarked that Aboudi and Bodner [127] used a unified theory for elastic-viscoplastic anisotropic work-hardening materials that does not require a yield condition and therefore avoids the difficulties associated with elastic unloading from a plastic state. The particular case of a dynamically loaded slab has been studied [127].

Marom and Bodner [128] presented a combined analytical and experimental study into the projectile perforation of multilayered beams. The theoretical analysis takes into consideration the effect of structural deformation on the perforation mechanism. The ballastic velocity is defined as the initial impact velocity for which the post perforation velocity equals the structural deformation velocity at the point of impact. Backman and Goldsmith [129] presented a valuable and comprehensive survey on the mechanics of penetration of projectiles into targets.

Another type of damage was considered by Vaughan [130] who conducted a large number of experimental tests on mild steel plates of various thicknesses penetrated in an in-plane sense by sharp rigid wedges. He proposed a formula that relates the external work done to the depth of penetration and wedge angle. This information is of considerable interest in calculations on the crashworthiness and grounding damage of ships and marine vehicles [131].

In other studies of dynamic plasticity the response of a rapidly heated rigid-plastic cantilever beam [132], and a thick-walled cylinder subjected to a sudden internal pressure [133] were examined. Polizzotto [134] considered the adaptation of discrete structures subjected to repeated dynamic loadings.

Experimental systems have been developed for applying dynamic loads to structures [135-137]. One simple device [136] is designed to impart a rectangular shaped force-time history with a duration on the order 10 ms to a structure. Other experimental arrangements [135, 137] are suitable for impulsive loadings.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles inlcude technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about plate vibration research, 1976 - 1980.

Dr. A.W. Leissa of Ohio State University, Columbus, Ohio has written the second paper of his two-part article summarizing recent research in free, transverse vibrations of plates. The first one dealt with problems governed by the classical theory of plates. The present one considers complicating effects such as anisotropy, in-plane force, variable thickness, surrounding media (e.g., air or water), large (nonlinear) transverse displacements, shear deformation, rotary inertia and nonhomogeneity.

PLATE VIBRATION RESEARCH, 1976 - 1980: COMPLICATING EFFECTS

A.W. Leissa*

Abstract. This paper is the second of two summarizing recent research in free, transverse vibrations of plates. The first one dealt with problems governed by the classical theory of plates. The present one considers complicating effects such as anisotropy, inplane force, variable thickness, surrounding media (e.g., air or water), large (nonlinear) transverse displacements, shear deformation, rotary inertia and nonhomogeneity.

INTRODUCTION

This is the second part of a review aimed at summarizing the current literature of plate vibrations. The previous part [1] was limited to problems governed by the most simple, classical theory. The present paper extends the survey to include complicating effects, and is the chronological sequel to another survey paper which encompassed the same scope for the preceding time period [2].

Complicating effects are those which directly affect the governing differential equation of motion for a plate. The effects to be considered in the present paper (as in [2]) include:

- Anisotropy
- Inplane forces
- Variable thickness
- Surrounding media
- Large deflections
- Shear deformation and rotary inertia
- Nonhomogeneity

The differential equation of motion (Equation 1) may be considerably complicated by the presence of one or more of the effects listed above.

$$D\nabla^4 w + \rho \frac{\partial^2 w}{\partial t^2} = 0 \qquad (1)$$

The resulting types of complications in the equation include:

- Additional terms of mixed differential order
- Variable coefficients
- Nonlinearity
- Increased differential order of the system (from fourth to sixth or eighth or greater) because of coupling

All of these effects tend to make the possibility less likely for finding exact solutions, and increase the number of parameters in the problem. In spite of all this, however, plate vibration problems are typically less complicated than those of shells [3].

The mathematical details of the complications which arise will not be elaborated upon here. To some extent they have been indicated in the previous paper [2]. Further details for the governing equations of motion are given in [4].

ANISOTROPIC PLATES

Compared with isotropic plates which are characterized by single flexural rigidity coefficient (D), anisotropic plates are considerably complicated by the need for defining five independent rigidity coefficients. Orthotropy is a special case of anisotropy, reducing the number of required coefficients to three. Typically, because of the large number of parameters required, one can find very few results for generally anisotropic plates in the literature. Solutions are generally confined to orthotropic plates which, fortunately, do represent a wide class of practical problems.

Orthotropy only requires that the material properties (viz., Young's modulus) have principal axes which

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are mutually orthogonal. Thus, although most results can be found for the relatively simple (but practical) case of rectangular orthotropy, curvilinear orthotropy can exist for an unlimited number of orthogonal coordinate systems (e.g., elliptic-hyperbolic coordinates). But among the latter possibilities, results only for the case of polar orthotropy are found where the principal axes are defined by the well known plane polar coordinates.

Polar Orthotropy

Relatively little recent research deals with the vibrations of plates possessing polar orthotropy. Ginesu, Picasso and Priolo [5] used finite elements to analyze annular disks. They also obtained experimental results, by means of real time and time average holographic interferometry. Lizarev, Klenov and Rostanina [6] developed exact solutions of the equation of motion in terms of generalized hypergeometric functions.

Irie, Yamada and Ito [7] took up problems of circular sector plates having polar orthotropy. Spline functions consisting of the products of deflection of sectorial beams and circular beams were used as admissible functions for a Ritz analysis. Extensive numerical results for frequencies and mode shapes were presented.

Rectangular Orthotropy

Dickinson [8] made a very useful extension of Warburton's [9] famous paper which gave a simple, approximate formula for the vibration frequencies of rectangular plates, based upon using Rayleigh's method with assumed modes in the form of products of vibrating beam functions. Dickinson's paper generalized the previous work to rectangular plates of orthotropic material (the so-called case of "special orthotropy" wherein orthotropy axes and plate edges are parallel). All 21 combinations of classical edge support conditions (clamped, simply supported or free) are accommodated in the formula. Comparisons were made with other published results in the literature.

Kuttler and Sigillito [9] demonstrated the application of a useful method for obtaining both rigorous upper and lower bounds of eigenvalues upon the clamped orthotropic plate problem. The method is computationally similar to the Ritz method, but the trial functions need not satisfy any of the boundary conditions. Upper and lower bounds for the same problem were also obtained by Marangoni, Cook and Basavanhally [10]. Other recent solutions of rectangular orthotropic plate problems for classical boundary conditions have been obtained using finite differences [11], finite elements [12] and a modified Bolotin asymptotic method [13].

Laura and Grossi [14, 15] examined rectangular, orthotropic plates having one or more edges elastically restrained against rotation. Numerical solutions for frequencies were achieved using the Ritz method with algebraic polynomials of low degree. Similar problems were also analyzed by Greimel [16].

Bert [17] and Sakata [18-20] have developed procedures which are potentially very useful for estimating the natural frequency of an orthotropic plate from that of the isotropic one having the same shape. Laura, Luisoni and Sarmiento [21] analyzed orthotropic plates of regular polygonal shape having both simply supported and clamped boundaries. Irie and Yamada [22] treated orthotropic annular plates of circular and elliptical shape using the Ritz method with spline functions.

INPLANE FORCES

Inplane forces are considered to be those initially applied to a plate, acting in its plane, and remaining constant during the vibratory motion (i.e., independent of vibration amplitude). They may be generated by forces acting along the boundaries or by body forces (e.g., gravity, centrifugal, magnetic). The inplane force field is completely determined within the plate region before the free vibration problem is addressed. This involves solving a plane stress problem in elasticity to determine the three components of stress at each point. If the inplane stresses (and resulting forces, which are the stresses times the thickness) are everywhere constant, then the resulting differential equation of transverse, vibratory motion has constant coefficients, and the resulting vibration problem is simplified.

Problems exist for every conceivable geometric shape of plate, subjected to any initial, inplane force field which satisfies the equations of plane elasticity. Tensile inplane forces cause the frequencies to increase, whereas compressive and shear forces cause them to decrease, the latter to a lesser degree.

Compressive or shear forces of sufficient magnitude are capable of reducing the fundamental natural frequency of a plate to zero, which corresponds to the linear, bifurcation buckling problem for a plate subjected to the given inplane forces.

Circular and Annular Plates

The circular plate loaded by a constant (i.e., hydrostatic) inplane force, simply supported and constrained elastically against rotation, and carrying a concentrated mass near its center was analyzed by Laura and Gelos [23].

Annular plates subjected to uniform inplane boundary forces have also been studied [24-25]. Ramaiah [24] gave results for eight different combinations of clamped, simply supported and free edge support conditions at the inner and outer boundaries. Previously, an interesting method of using a coordinate transformation was demonstrated, which results in numerically well-behaved solutions, even for annular plates of narrow width [25]. The clamped-free annular plate subjected to a concentrated force on the outer boundary was analyzed by Srinivasan and Ramamurti [26].

Rotating circular disks give rise to nonuniform centrifugal inplane forces and interesting vibration problems [27-31]. For example, each nodal pattern for nonrotating circular and annular disks has ***two*** frequencies associated with it in the rotating case. MacBain, Horner, Stange and Ogg [27, 28] showed how holographic interferometry may be used to determine frequencies and mode shapes of clamped-free disks.

The concept of optimizing the initial stress field in a circular plate so as to maximize its frequency was studied by Rammerstorfer and Beer [32, 33]. Nayfeh, Kamat and Ramkumar [34, 35] developed an interesting method to reduce the problem of a highly prestressed anisotropic plate into the more simple problem of an anisotropic membrane with modified boundary conditions that account for the effects of bending.

Rectangular Plates

Dickinson's formula [8] for orthotropic rectangular plates having arbitrary edge conditions (see preceding section) also included the effects of uniform axial stresses.

Kielb and Han [36] presented extensive numerical results for the fundamental frequencies and mode shapes of rectangular plates loaded by inplane hydrostatic forces for all six possible combinations of simply supported and clamped boundary conditions. Exact solutions were used for the three cases having two opposite sides simply supported, and approximate series solutions for the other three. A number of other solutions by approximate methods exist for rectangular plates with inplane loads [37-40]. The effects of thermal gradients upon vibrations has also been considered [41, 42].

Bassily and Dickinson [43] outlined a unified Ritz approach for determining both the initial inplane forces (i.e., solution of the plane stress problem) and finding vibration frequencies and mode shapes. The method was demonstrated on the problem of the cantilever plate subjected to inplane acceleration loads which had a previous solution [44] and three other less complicated loadings. Porter Goff [45] also solved an interesting problem involving nonuniform inplane loads -- the completely free rectangular plate having self-equilibrating residual stresses arising from running a weld along a longitudinal centerline.

Laura and his colleagues [46-48] have recently analyzed several problems involving rectangular plates having one or more edges elastically constrained, and subjected to combinations of inplane normal and shear loads. The Galerkin method with simple algebraic polynomials was used. The rectangular simply supported plate subjected to uniaxial inplane forces and restrained by translational springs at two internal points has also been studied [49].

Other Shapes

A few solutions are available for other shapes. Laura and Gutierrez [50, 51] used conformal mapping together with the Galerkin method to study shapes for which mapping functions are known, such as polygonal plates, subjected to hydrostatic inplane forces. Datta and White [52] considered the rectangular plate having a central opening.

VARIABLE THICKNESS

The writer was rather surprised at the amount of attention paid to variable thickness plates in recent years. The effect of variable thickness is to cause variable coefficients in the differential equation of motion, making their exact solution very difficult.

The present survey is limited to plates of ***continuously varying*** thickness. Plates of stepped thickness are straightforwardly treated as two or more constant thickness plates joined together at their intersections by continuity conditions, and will therefore be regarded as structures composed of multiple elements and beyond the scope of this review.

Circular and Annular Plates

Particularly notable is the work of Lenox and Conway [53] who obtained an exact, closed form solution for the case of an annular plate having a parabolic thickness variation. The solution of the equation of motion is found to be expressible in the exact, closed form

$$w(r, \theta, t) = (A_1 r^{\lambda_1} + A_2 r^{\lambda_2} + A_3 r^{\lambda_3} + A_4 r^{\lambda_4}) \cos m\theta \sin \omega t \tag{2}$$

and numerical results are given for the three cases of outer-inner boundaries being clamped-clamped, simply supported-free and free-free. This work is an excellent addition to the exact solutions previously achieved by the senior author [54, 55] many years ago. Indeed, it is even better, for the previous solutions required the use of Bessel functions, which are necessarily expressed in infinite series. Irie and Yamada [56] also obtained results for the annular plate having parabolic thickness variation.

Recent papers have also treated circular and/or annular plates having linear [56-58] and exponential [56] thickness variation. A Ritz approach was straightforwardly used [59] to analyze the class of plates having thickness variations

$$h = h_o (1 + a/r^m) \tag{3}$$

Several recent works have dealt with the problem of optimizing the thickness variation to control the resulting frequencies [60-63].

Laura and his colleagues [64-67] have solved a number of problems involving the vibrations of variable thickness circular plates having elastic constraints along their edges, including the case where the boundary stiffness is varying circumferentially [67]. Ritz-Galerkin procedures with algebraic polynomial trial functions were used.

Rotating variable thickness disks occur in steam and gas turbine applications and have received some attention [68-71]. In these cases the calculation of the initial inplane forces arising from centripetal acceleration is in itself a significant problem. Variable thickness disks having uniform, hydrostatic inplane forces have also been treated [72, 73].

Rectangular Plates

Sakata [74-76] has dealt with a number of rectangular plate problems having ***linearly*** varying thickness. These include the cases of all sides simply supported [74]; SFSS and SFSF [75]; and all sides clamped [76]. Laura and his colleagues [77-78] have taken up problems of linear thickness variation where the thickness gradients are not necessarily the same in two halves of the plate. Such a situation also occurs in the case of a solid wing structure of diamond-shaped profile which is modeled as a variable thickness cantilever plate [79].

Plates having parabolic [80, 81] and exponential [82] thickness variations have also been considered.

Laura and his colleagues [83-85] also took up problems for variable thickness rectangular plates having elastic constraints along one or more of the edges. Linear taper was considered, and the remaining edges were either clamped or simply supported.

Several other interesting papers exist [86-91] for variable thickness rectangular plates. Finite difference [87, 88] and finite element [89] methods were demonstrated, as well as a straightforward procedure representing a continuously varying thickness by a stepped thickness plate [90]. The optimization problem was also treated [91].

Other Shapes

Banerjee [92] analyzed plates of parallelogram shape. Results were obtained for different ratios of the sides, skew angle and taper constant. Annular sectors of nonuniform thickness were studied by Bhattacharya [93]. The straight edges were clamped and the inner and outer circular edges were both either clamped or simply supported.

EFFECTS OF SURROUNDING MEDIA

Classical analysis assumes that a plate is vibrating in a vacuum. The effect of surrounding fluids, such as air or water, is to introduce mass coupling with these media, thereby decreasing the vibration frequencies. Several recent papers have taken up plates immersed in water [94-97]. These have included both finite element analyses [94-96] and an experimental study [97].

The effect of a classical elastic foundation distributed along one or both lateral faces of a plate is to increase its natural frequencies. In the most common case of a uniformly distributed elastic foundation having a linear spring coefficient, the problem modification is a minor one, and the numerical results for conventional, constant-thickness plates are readily adjustable to account for the elastic foundation (cf., [4], p 1). However, when the elastic foundation is distributed along only part of a lateral face, the problem is considerably more complicated. Nagaya, Hirano and Okazaki [98, 99] studied the circular plate supported elastically on an eccentric region which is either circular [98] or annular [99] in shape. Bhattacharya [100] considered simply supported triangular plates which rest on a Vlasov-type elastic foundation.

LARGE DEFLECTIONS

Large transverse deflection (w) of a plate causes an additional, membrane-type of stiffening to be present. The additional stiffening is the result of the capability of the plate to generate displacement-dependent inplane forces, and is therefore very much dependent upon the inplane constraints at the boundary. The equation of transverse motion becomes coupled with the plane compatibility equation governing inplane stretching, and both equations are nonlinear. The resulting nonlinearity is of the "hardening" type; that is, the vibration frequencies increase with increasing amplitude of motion (cf. [4], pp 303-314). This frequency increase can become quite significant for vibration amplitudes on the order of half the plate thickness, or more.

It is unfortunate that so many authors persist in presenting numerical results showing the ratio of the nonlinear ***period*** of free vibration to the linear one, as a function of the amplitude-to-thickness ratio. Engineers are primarily interested in the inverse relationship; that is, the ratio of nonlinear ***frequency*** to the linear one.

Circular and Annular Plates

A number of recent works [101-104] deal with circular plates having various boundary conditions and subjected to large amplitude vibrations. Results were also obtained by Kanaka Raju [105] for clamped and simply supported plates carrying a point mass, and with Venkateswara Rao [106] for annular plates having their inner and outer boundaries elastically restrained against rotation.

A series of studies were also conducted by the aforementioned authors on the nonlinear vibrations of circular plates having the additional complicating effects of orthotropy [107, 108] and initial thermal stresses [109]. Dugdale [110] analyzed the centrally clamped, rotating circular disk, which is important in the design of efficient, thin circular saws.

Large amplitude vibrations of variable thickness circular plates were investigated by Kanaka Raju and Venkateswara Rao [111, 112], including the case of elastic boundary constraint [112]. Finite elements were used. Huang and Aurora [113] treated orthotropic plates of variable thickness.

Rectangular Plates

Nonlinear vibration studies for rectangular plates have been carried out by a number of authors [114-119] for various types of boundary conditions showing the importance of inplane restraint at the boundaries. Karmakar [120] added the effects of a concentrated mass to the problem, whereas others considered the effects of orthotropy in the nonlinear analysis [121-123]. Banerjee [124] treated nonuniform rectangular plates.

Other Shapes

Considering the difficulty involved in dealing simultaneously with irregular boundary shape as well as with geometric nonlinearity, quite a few solutions can be found for plates other than circular or rectangular [125-135]. Results are available for the elliptic plate [125, 126], including the case of a clamped plate carrying a concentrated mass [127]. Several works have studied plates of parallelogram shape [128-131], even for the case of anisotropic material

[130]. Triangular shapes have been analyzed [128-132]. Datta and Banerjee [133-134] used a conformal mapping method to accommodate regular polygonal shapes, for both simply supported and clamped boundary conditions. Sectorial plates having their straight, radial edges simply supported and the circular edge elastically supported were also examined [135].

Other References

A number of other recent references which are also germane to the study of nonlinear, large deflection vibrations of plates should be mentioned [136-147]. A few of them [137, 142, 146] utilize finite element methods. Kunda and Basuli [143] considered the case of the plate resting on a Pasternak foundation, whose reaction is expressed by a term of the form $(k-G\nabla^2)w$ in the differential equation, and obtained results for circular, rectangular and triangular plates. Raju, Venkateswara Rao, and Kanaka Raju [141] studied the effects of inplane inertia coupling upon the motion. Several papers deal with the large amplitude vibrations of a plate subjected to initial, inplane prestress [136, 138, 140, 144, 145], in some cases considering the effects of initial imperfections [163, 138, 139].

SHEAR DEFORMATION AND ROTARY INERTIA

The effects of shear deformation and rotary inertia enter the problem in physical ways which are altogether different. Shear deformation affects the strain-displacement equations, permitting additional shear flexibility in the system, and relaxing the Poisson hypothesis that normals to the plate midsurface remain normal during deformation. Including it raises the differential order of the equation of transverse motion from fourth to sixth, and requires the statement of three mathematical boundary conditions per edge. Rotary inertia enters through the moment equilibrium equations for a plate element, generalized to include the dynamic rotational inertia terms. Both effects serve to decrease plate frequencies, although the shear deformation effect is usually somewhat more important, and both increase in significance as the thickness/width ratio of a plate increases. Thus, both effects are traditionally either jointly considered or neglected in a problem, and they are considered jointly here.

Circular and Annular Plates

George [148] studied the problem of the clamped circular disk to which a point mass and/or spring is attached at the center. Finite elements have been applied to annular plates clamped on the inner boundary and free at the outer [71, 149].

Variable thickness circular plates have received some attention [150, 151]. Irie, Yamada and Aomura [150] used the transfer matrix approach to analyze annular plates of linearly, parabolically and exponentially varying thickness. The effects of geometric nonlinearity (large deflections) were also incorporated into thick circular plate theory [152], and clamped and simply supported plates were analyzed.

Rectangular Plates

Dawe and Roufaeil [153] demonstrated how Timoshenko (i.e., thick) beam functions can be used with the Ritz method to analyze rectangular thick plates. Nelson [154] developed an asymptotic method, similar to the well-known one of Bolotin, to deal with thick plate boundary conditions. Finite strip [155, 156] and finite element [157] methods have also been further developed for thick rectangular plate vibration analysis.

The complicating effects of orthotropy [158-159], initial inplane forces [160] and large deflections [161-166] have all been treated with thick plate theories. Magrab [158] extended the Galerkin method to deal with orthotropic plates under any combination of simply supported, clamped or elastically supported boundary conditions. The nonlinear, large amplitude solutions were obtained using Galerkin [161], finite element [162, 163] and Runge-Kutta numerical integration [164, 165] techniques.

Other Shapes

Sathyamoorthy [167-171] and Chia [170, 171] have been involved with thick plates of parallelogram shape, including the nonlinear, large amplitude effects. Galerkin's method, together with Runge-Kutta numerical integration, was used to obtain numerical results. Kanaka Raju and Hinton [172] studied rhombic plates for small amplitude vibrations by means of finite elements. The ***existence*** of an infinite, discrete spectrum of eigenfrequencies and of a set of corresponding eigenmodes of vibrations for thick plates of arbitrary shape with clamped, simply supported and free edges was established by Cornwell and Yen [173].

Elasticity Theory

The thick plate vibration analyses described above were performed with two-dimensional, sixth order plate theory, usually of the type ascribed to Mindlin [174]. Such solutions are generally valid for very thick plates. However, in recent years considerable attention has been given to solutions obtained from the exact, three-dimensional theory of elasticity [175-188], which are valid for arbitrary thickness. In such cases the terminology "plate" loses its meaning, and descriptive terms such as "solid cylinder" or "rectangular parallelepiped" better describe the problem. Nevertheless, as computers and analytical procedures become more efficient, three-dimensional solutions will definitely become increasingly important in the future, not only for their own sake, but for verifying the accuracy of two-dimensional plate theories.

NONHOMOGENEITY

A plate is nonhomogeneous (or heterogeneous) if its material properties vary from point to point within it. Material properties can vary in the two tangential (x-y or r-θ) directions or in the normal (thickness) direction. Variation may be continuous or discontinuous. Continuously varying nonhomogeneity can occur naturally during the production of materials (e.g., styrofoam, rubber) or due to environmental effects (e.g., temperature). But discontinuous variation, especially through the thickness, has received much greater attention from researchers thus far. Such cases may be called "layered plates," with honeycomb and fibrous composite plates being special, important cases of layered plates.

Laminated composite plates are typically made up of layers having fibers (e.g., glass, boron) which are presumed to be parallel, imbedded in a matrix material (e.g., epoxy resin). The individual layers, which can be considered as homogeneous or orthotropic, are then stacked upon each other so that fibers of adjacent layers are typically not parallel (i.e., cross-ply or angle-ply). Such plates have become very important, and considerable vibration research has recently been devoted to them. But the recent research has been adequately summarized in review papers by Bert [189, 190] and the present writer [191], so that these types of plates will be omitted from this review.

Continuously Varying Nonhomogeneity

An isotropic circular plate with density varying parabolically with its radius, and clamped along its boundary, was studied by Pan [192]. Rectangular plates having linear variation in Young's modulus and mass density were analyzed by Prakasa Rao, Venkateswara Rao and Raju [193]. Perturbation and Galerkin methods were used. Ganesan and Dhotarad [194, 195] considered the effects of thermal gradients, with Young's modulus assumed to vary linearly with the temperature, upon rectangular plates. Thermal stresses were not induced. Random nonhomogeneity in rectangular plates was studied by Wood and Zaman [196, 197].

Layered Plates

Several recent papers have dealt with circular layered plates [198-203]. Stavsky, together with Elishakoff [199] and Greenberg [200, 201] analyzed plates composed of polar orthotropic layers. The effect of a pin hole at the center upon the frequencies was seen [201].

Vibrations of rectangular, layered plates were considered [204, 205], including the effects of large amplitude vibration [205].

SUMMARY

A very large amount of research in plate vibrations has taken place during the past four years, especially with the more difficult problems posed by inclusion of complicating effects. More publications dealing with these problems have appeared during the past four years than in all the time preceding the year 1966 [4]. Particularly large increases have occurred for studies dealing with variable thickness, large deflections and laminated composite plates.

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BOOK REVIEWS

THE DYNAMICS OF THE UPPER OCEAN

O.M. Phillips
Cambridge University Press, New Rochelle, NY
1977, Second Edition, 336 pages, $49.95

Those who have read and enjoyed the classical first edition will find this new edition welcome. Most (but not all) of the earlier material has been carried forward; new material has been added on energy exchange in wave trains, surface wave interactions, the saturation range of ocean surface waves, and the low frequency regime of internal waves. The result is very much in the style of the previous edition, but the coverage is more extensive.

Chapter 2 contains the author's notation and basic equations. A treatment of wave trains is followed by a general discussion of surface waves in Chapter 3. Specifications of the wave field of ocean surface waves are given. The topics are treated in terms of their probability and spectral attributes. Chapter 5 treats internal waves and low frequency oscillations. The final chapter deals with oceanic turbulence.

Readers approaching the subject for the first time might be disappointed. No mention is made of the computational advances that have occurred during the decade between the editions or of the numerical methods that are now applied to describe the gross transport of mechanical energy in arbitrary media, including the oceans. The second edition will thus strike some as historical, rather than practical, in contrast to the first edition.

This book could be considered a catalog of models, more or less useful, for describing the dynamics of the upper ocean. Data are occasionally produced to verify and refine the models. The strength of the work lies in the eclectic overview of the models, which (including the data) give the reader some comprehension of this large and important subject.

The weakness is that common to the English school -- assumptions underlying the models are seldom clearly expressed. Consequently the validity of the models, and even more importantly their extensions, is often questionable. Thus costly experimental verification is required in a notoriously changeable medium.

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Office of Engineering Mechanics
Naval Underwater Systems Center
New London, CT 06320

TECHNIQUES OF FINITE ELEMENTS

B. Irons and S. Ahmad
John Wiley and Sons, Inc., Somerset, NJ
1980, $72.00

Since the advent in the early 1960s of the finite-element method for solving complex engineering problems, a substantial number of textbooks have been published. The objective of this book is somewhat different from other texts on the subject: at the conclusion of the text the authors state, "we hope our telling of the story is sufficiently different to win us enemies as well as friends – for otherwise, what is the point?" Before commenting on whether their efforts to be different are for the better, the reviewer will consider who is the intended audience. According to the book jacket the readership is for "Engineers in mid-career, managers involved with finite-element decisions. Teachers of structural mechanics, postgraduate students. Aerodynamicists, etc., seeking additional physical insight, programmers lacking engineering background of finite elements."

Individuals seeking to learn finite-element analysis for the first time are missing from the authors' intended readership. This point is evident from the manner in which such important finite-element concepts as the development of the finite-element stiffness matrix and the element shape functions are introduced in the first three chapters. Although these concepts are covered in the beginning of the text as if the reader were being introduced to them for the first time, the beginner would find the text relatively hard to follow and would be better off with other texts for an introductory point of view. On the other hand, the reader who already has a good idea of how shape functions and stiffness matrices are derived will find in the book a wealth of material and interesting points of view on a wide variety of finite-element related concepts not usually covered in other finite-element texts. For this reason, the book would be a good supplement to more conventional texts; however, those who will need only one finite-element book will find that the text is not as broad in scope as it should be. For example, the areas of structural dynamics, nonlinearities, and nonstructural finite-element applications are given rather light coverage. This is perhaps compensated for by the good coverage of topics that are usually missing in other texts -- discussions of the significance and application of the patch test and dangers of the implicit mechanism present in some elements, detailed information concerning frontal solution packages, and roundoff error discussions.

A brief sketch of the contents and comments are given below. The book is divided into seven main parts, each of which contains a number of chapters.

Part I, Introduction, contains some interesting concepts about the finite element method as a whole, including an example of how element global stiffness matrices are assembled from individual stiffnesses. Such important notions of finite elements as shape functions; various beam, plate, and solid elements; and various elastic problems are covered. However, in the reviewer's opinion the reader not already familiar with shape functions and stiffness matrix derivations would find the presentation difficult to understand. For example, shape functions, introduced in Chapter 2, are simply written down for a beam example; no explanation is given of how they are derived.

In Part II on organization are such topics as finite-element computer program management, matrix structural theory, matched solutions, convergence by the patch test, and developing and implementing elements. It is surprising that the explanation of how to apply a patch test is not clearly presented, particularly in view of the fact that one of the authors invented the test. They present three applications of the patch test to the boundary node of a patch: "(a) we can impose deflections that would give the constant stress, (b) we can calculate the nodal loads caused by the traction along the boundary edges, or (c) we can impose deflections at every node." The reader might wonder about the difference between (a) and (c).

Part III, Solution Techniques, treats the following topics: how nodes hang together in a front or band type matrix assembly, methods of element assembly and subsequent equation solving, details of a frontal solution package (easily readable FORTRAN listings are provided), and a good section on roundoff errors. This reviewer did not find the frontal solver explanation very clear; e.g., why not warn the reader in advance that this method is different from other solvers in that the stiffness matrix assembly and Gauss elimination reduction are done simultaneously. The reader might eventually figure out the dual operation after rereading the explanation several times, but advance warning would add to the understanding of the method.

Parts IV and V contain information about trends in element formulation and solution techniques. Useful sections on symmetry and sectorial symmetry are included that are not usually found in texts on the subject. Part VI on speculation contains useful discussions on nonstructural problems and implications of the patch test. In Part VII on theoretical details are covered such mathematical topics as interpolation and numerical integration, matrices, vectors/differential geometry, and stress-strain relations.

In summary, the reviewer agrees with the authors that their telling of the story is sufficiently different to win them enemies and friends. Some will not like their "deliberately written in conversational style" approach; extreme examples, admittedly taken out of context from Chapter 6, are, "That's all I can think of, now. Exciting isn't it?" and "Oh, I nearly forgot. True story so they tell me." All things considered, however, the pluses still outnumber the minuses. The reviewer is "a friend" and thus would recommend the book, despite the negative comments sprinkled throughout this review.

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VARIATIONAL METHODS IN THEORETICAL MECHANICS

J.T. Oden and J.N. Reddy
Springer-Verlag, Vienna and New York
1976, $16.50

Variational methods play an important role in theoretical mechanics, provide good approximations, and can be considered the heart of the most powerful procedures used in mechanics. As stated by the authors, "variational formulations can serve not only to unify diverse fields but also to suggest new theories, and they provide a powerful means for studying the existence of solutions to partial differential equations."

Chapters I and II discuss variational methods and Banach spaces. The latter emphasize the Gatreaux and Fresnel differentials and their relationships. Mean value theorems and Taylor's formula are considered; insight is given into the basics of variational theory. Sobelar spaces, a special form of Banach spaces, are described.

Chapters III and IV contain a brief review of the mathematics of continua and very theoretical discussions of the mechanical laws of balance, the principles of the conservation of mass and thermodynamics (conservation of energy), and the constitutive theory with equations applied to materials. The authors consider the theory of complementary and dual variational principles. These principles apply to a large class of linear boundary and initial value problems of mechanics. The authors present a unified theory. They present this difficult concept in terms of operators applied to variational principles. Examples include elastodynamics, linear elasticity, fluid mechanics, magnetostatics, and electrostatics. The 14 fundamental complementary-dual principle concepts are described -- upper and lower bounds to some quantities that have a relationship to the functionals.

Chapter V is the heart of the book and is devoted to a representative collection of variational principles of continuum mechanics. A general method for developing these principles is explained; a number of examples in such areas of solid and continuum mechanics as dynamics, vibrations, and acoustics are given. The authors apply variational principles to a number of specially selected areas; i.e., dynamic linear coupled thermoviscoelasticity, linear and piezoelectric elastodynamics, fluid mechanics, and magnetohydrodynamics. Non-newtonian fluids and discontinuous field equations are briefly considered. Gurtin's variational principle is applied to viscoelasticity in a novel approach.

Chapter VI describes variational boundary value problems, including elliptical boundary value problems, Hilbert's space, the Lax-Milgram-Babuska theorem for linear variational boundary value problems, and the existence theory in nonlinear elasticity.

Chapter VII considers the variational methods of approximations, namely Galerkin's method, Rayleigh-Ritz method, collocation methods, the method of weighted residuals, finite-element approximations, and finite-element interpolation theory. The authors neglect the important hybrid finite-element theory.

In summary, the reviewer found this book to be highly theoretical. Basic functional theory and continuum mechanics are prerequisites. The reviewer further believes that the text would be more applicable to acousticians, engineers, and scientists if more down to earth mathematics were given instead of the abstract and highly theoretical mathematics presented. This book is meant for an advanced college course.

H. Saunders
General Electric Company
Schenectady, NY 12345

SHORT COURSES

NOVEMBER

ENGINEERING APPLICATIONS OF CORRELATION AND SPECTRAL ANALYSIS

Dates: November 2-5, 1981
Place: Washington, D.C.
Objective: This four-day short course covers important engineering applications of correlation and spectral analysis relative to acoustics, mechanical vibrations, system identification and fluid dynamics problems in the aerospace, automotive, industrial noise control, civil engineering and oceanographic fields. Applications include identification of system properties and response effects, estimation of time delays and propagation velocities, determination of energy sources, and utilization of practical statistical error formulas to evaluate results. Comprehensive methods are explained to solve single input/single output problems, single input/multiple output problems and multiple input/multiple output problems, where arbitrary correlation and coherence functions (ordinary, partial, multiple) can exist among the records. Participants will be able to have questions answered that are of concern to their own individual projects.

Contact: Continuing Education Institute, 10889 Wilshire Blvd., Suite 1030, Los Angeles, CA 90024 - (213) 824-9545 or Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044 - (301) 596-0111.

MACHINERY VIBRATION ANALYSIS

Dates: November 3-6, 1981
Place: Atlanta, Georgia
Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow speed paper rolls.

Contact: Dr. Ronald L. Eshleman, The Vibration Institute, 101 West 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

CONTROLLING THE EFFECT OF PULSATIONS AND FLUID TRANSIENTS IN PIPING SYSTEMS

Dates: November 4-6, 1981
Place: San Antonio, Texas
Objective: This open seminar on piping dynamics is being repeated at industry request. Participants will be provided the available techniques for diagnosing problems and controlling their effects in dealing with typical, practical plant problems. Although the technology involved is applicable to a broad spectrum of industrial problems, its primary utilization has been by energy-related industries such as natural gas, oil, refining, chemical, petrochemical, electric power generation, equipment manufacturing, architectural and engineering firms, and others. The seminar will be beneficial to technical, professional and managerial personnel in all related industries.

Contact: Joe Gulinson, Applied Physics Division, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78284 - (512) 684-5111, Ext. 2521.

19TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 9-13, 1981
Place: Tucson, Arizona
Objective: Emphasis will be on reliability engineering theory and practice; mechanical reliability predic-

tion; reliability testing and demonstration, reliability data sources, maintainability engineering, and life cycle costing; product liability; reliability and maintainability management, and life-cycle costing. The Institute is designed for engineers and managers in reliability, product assurance, QC, manufacturing, sales and service; other engineers, statisticians, government and industry representatives, plus college and university teachers.

Contact: Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Dept., Building 16, The University of Arizona, Tucson, AZ 85721 - (602) 626-2495, 626-3901, or 626-3054.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: November 16-20, 1981
Place: Santa Barbara, California
Dates: December 8-12, 1981
Place: Huntsville, Alabama
Dates: February 1-5, 1982
Place: Santa Barbara, California
Dates: March 1-5, 1982
Place: College Park, Maryland
Dates: April 12-16, 1982
Place: Dayton, Ohio
Dates: July 19-23, 1982
Place: England
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barba, CA 93105 - (815) 682-7171.

COMPUTER TECHNIQUES FOR DYNAMIC STRUCTURAL DESIGN

Dates: November 24-26, 1981
Place: Southampton, England
Objective: Topics include: introduction to approximate methods of structural vibration analysis: Rayleigh-Ritz and finite element methods; vibration of frame type structures; finite element modeling of structures; data preparation for finite element programs; vibration of plate structures; vibration of shell structures; assessing the accuracy of elements; computer graphics as an aid to structural design; choice of solution techniques; eigenvalue problems, reduction methods; substructuring; transient response.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton S09 5NH - (0703) 559122, Ext. 2310.

DECEMBER

MACHINERY DATA ACQUISITION

Dates: December 7-11, 1981
Place: Carson City, Nevada
Objective: This seminar is designed for people whose function is to acquire machinery data for dynamic analysis, using specialized instrumentation, and/or that person responsible for interpreting and analyzing the data for the purpose of corrective action on machines. Topics include measurement and analysis parameters, basic instrumentation review, data collection and reduction techniques, fundamental rotor behavior, explanation and symptoms of common machinery malfunctions, including demonstrations and case histories. The week also includes a lab workshop day with hands-on operation of the instrumentation and demonstration units by the participants.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-3611, Ext. 224.

FEBRUARY

VIBRATION TESTING AND SIGNAL ANALYSIS

Dates: February 16-18, 1982
Place: Southampton, England
Objective: Topics include: types of testing: introduction to the various types of signal-linear system theory, etc. (i) testing with applied excitation - techniques - steady state, slow sweep, transient, random, (ii) response analysis (only) - system in motion due to natural excitation; instrumentation and signal conditioning - effects of attachments on system characteristics; instrumentation system characteristics; limita-

tions, e.g. bandwidth, integration, analogue filtering, etc.; signal processing; and specification testing.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH - (0703) 559122, Ext. 2310.

BALANCING OF ROTATING MACHINERY

Dates: February 23-25, 1982

Place: Houston, Texas

Objective: The seminar will emphasize the practical aspects of balancing in the shop and in the field. The instrumentation, techniques, and equipment pertinent to balancing will be elaborated with case histories. Demonstrations of techniques with appropriate instrumentation and equipment are scheduled. Specific topics include: basic balancing techniques (one- and two-plane), field balancing, balancing without phase measurement, balancing machines, use of programmable calculators, balancing sensitivity, flexible rotor balancing, and effect of residual shaft bow on unbalance.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MARCH

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 1-5, 1982

Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS

Dates: March 8-12, 1982

Place: Phoenix, Arizona

Objective: Program emphasis is on how to increase productivity, cost-effectiveness of data acquisition systems and groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

SHOCK AND VIBRATION CONTROL

Dates: March 16-18, 1982

Place: Southampton, England

Objective: Topics include: introduction - structural parameters and their role in vibration control; dynamic properties of structural materials - damping materials and their properties, application of damping treatments to structures, fibre reinforced plastics, fatigue; mobility methods - concepts, system coupling, application to the isolation problem, approximate methods; vibration transmission through structures - path identification - classical, cross correlation, etc., power flow - mechanisms, use of statistical energy methods, acoustic radiation, radiation efficiency; shock - impacts in machines - effects of structural parameters on acoustic radiation, isolation - machinery installations, the transient environment - packaging and packaging materials.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH (0703) 559122, Ext. 2310.

APRIL

DESIGN OF FIXED OFFSHORE PLATFORMS

Dates: April 5-16, 1982

Place: Austin, Texas

Objective: This course is dedicated to the professional development of those engineers, scientists, and technologists who are and will be designing fixed offshore platforms to function in the ocean environment from the present into the twenty-first century. The overall objective is to provide participants with an understanding of the design and construction of fixed platforms, specifically the theory and processes of such design and the use of current, applicable engineering methods.

Contact: Continuing Engineering Studies, College of Engineering, Ernest Cockrell Hall 2.102, The University of Texas at Austin, Austin, TX 78712 - (512) 471-3506.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

Call for Papers

MECHANICAL FAILURES PREVENTION GROUP 35TH SYMPOSIUM
April 20-22, 1982
Gaithersburg, Maryland

The Mechanical Failures Prevention Group (MFPG), under the sponsorship of the National Bureau of Standards, will hold its 35th Symposium at the National Bureau of Standards, Gaithersburg, Maryland, April 20-22, 1982.

The meeting will focus on the prevention of failure resulting from time-dependent mechanisms. Emphasis will be on the critical evaluation of input data through the use of in-service inspection and condition monitoring and the comparison of existing assessment methodologies or failure prediction approaches. The objectives will be to:

- evaluate and present data in such a way that it can be efficiently used to assess the time-dependent failure problem, and
- identify the necessary changes in design, fabrication processes, or service conditions needed to reduce the chance of failure.

Contributions are desired in, but not limited to, the following areas of interest:

- Time-Dependent Failure Mechanisms

  Corrosion including stress corrosion cracking
  Fatigue and corrosion fatigue
  Creep and materials degradation, e.g. embrittlement of metals

- Data Accumulation and Assessment

  Role of data bases and standard reference data
  Data modeling and reliability including laboratory testing vs. full-scale testing
  Condition monitoring and surveillance

- Assessment Methodologies

  Life cycle concepts and risk analysis
  Structural integrity vs. fitness for purpose criteria
  Failure assessment diagrams
  Deterministic vs. probabilistic methods

The proceedings of this Symposium will be published by the National Bureau of Standards, distributed to all conference attendees, and will be publicly available through the Government Printing Office.

An early response including title of your presentation and short abstract (200 - 300 words) would be appreciated. The closing date for abstracts is November 22, 1981.

For further information, contact: Dr. James G. Early, National Bureau of Standards, Building 223/Room A-113, Washington, DC 20234 - (301) 921-2976.

Call for Papers

13TH ANNUAL PITTSBURGH CONFERENCE ON MODELING AND SIMULATION
April 22-23, 1982
Pittsburgh, Pennsylvania

The 13th Annual Pittsburgh Conference on Modeling and Simulation, sponsored by the School of Engineering - University of Pittsburgh, will be held April 22-23, 1982.

Special emphasis for the 1982 Conference will be microprocessors and their applications as well as energy, social, economic, and global modeling and simulation and papers on all traditional areas of modeling and simulation.

Only papers which have not been published previously will be considered. These papers should describe significant contributions which add to the knowledge in a particular area or which describe the origin and progress of research that is being currently conducted. All papers submitted and accepted for presentation at the Conference will be considered for publication in the Proceedings. There will be a length limitation on all papers but additional space in the Proceedings may be purchased at a nominal cost.

Two copies of titles, authors, all authors' addresses, abstracts and summaries should be submitted by January 31, 1982. The abstract should be approximately 50 words in length and the summary should be of sufficient length and detail to permit careful evaluation. Identify one author as the correspondent for the paper. All communications will be with this author. Notification of acceptance for presentation will be given by March 6, 1982. Instructions and model paper for the preparation of accepted papers will be mailed to each author. The final typed manuscript will be due by April 23, 1982.

For further information, contact: William G. Vogt or Marlin H. Mickle, Modeling and Simulation Conference, 348 Benedum Engineering Hall, University of Pittsburgh, Pittsburgh, PA 15261.

INFORMATION RESOURCES

CONCRETE TECHNOLOGY INFORMATION ANALYSIS CENTER

INTRODUCTION

The U.S. Army Corps of Engineers has been deeply involved in concrete technology -- the intelligent use of concrete as a construction material -- for nearly two centuries. Such involvement in concrete technology inevitably includes analysis of information on concrete technology. Since concrete technology is an important element of the technological base of the civilian economy as well as of military technology, there has necessarily been an interchange of information between the military and civilian sectors and the public and private sectors. The research and development center for concrete technology of the Corps of Engineers, the U.S. Army Engineer Waterways Experiment Station (WES), has been and is the principal point of contact for information exchange within the Federal establishment, the Defense establishment, and between these and the civilian and private sectors of the economy. It was, therefore, highly appropriate that when a Department of Defense (DoD) Concrete Technology Information Analysis Center (CTIAC) was establsihed on 18 April 1968, it was established at the WES and that its Director be the Chief, Concrete Laboratory* (CL), WES.

BACKGROUND

Under date of 17 March 1965, the Office, Chief of Engineers (OCE), requested the Director, WES, to review AR 70-22 "Centers for Analysis of Scientific and Technical Information" and comment on the extent to which WES was already engaged in work of this sort, areas for which establishment of centers at WES should be considered, and related topics. In reply, it was stated that WES was rather deeply engaged in this sort of activity and recommended consideration of the establishment of several centers, one of which was in the area of concrete technology which would deal specifically with (a) mass concrete materials and construction methods, (b) analytical p· cedures and test methods, and (c) portland cement grout mixtures; with initial service responsibility to the DoD. It was noted that the WES Concrete Laboratory had gathered, analyzed, evaluated, condensed, and published reports on the state-of-knowledge or state-of-the-art in a number of areas, and that the capability of its staff is superior to that found elsewhere in the world for treating some of these areas.

In August 1965, in accordance with AR 70-22, a proposal for establishment of the center was sent from WES to OCE. It was proposed that the CTIAC draw upon the work of other groups such as the Centre Internationale du Batiment (CIB), CEMBUREAU, Portland Cement Association (PCA), American Concrete Institute (ACI), Highway Research Board (HRB), American Society for Testing and Materials (ASTM), RILEM, National Bureau of Standards (NBS), etc.

In April 1966, OCE submitted proposals to the Office, Chief of Research and Development (OCRD), for approval of the establishment of eight centers to serve the DoD. The CTIAC was established by memorandum dated 18 April 1968 from the Director, Defense Research and Engineering (DDRE), to the Assistant Secretary of the Army, R&D.

On 29 April 1970, TISA Project 02/07, "Cost Analysis of Information Centers," was begun to develop information relative to the level of effort being expended by the Waterways Experiment Station Technical Library and the staff of the Concrete Division in the operation of the Concrete Technology Information Analysis Center. Information collected included the activity that was conducted and its nature, the clientele served, and the cost. A member of the technical staff of the CL was assigned as project leader. The CL staff and the WES Library kept records of requests for services from CTIAC,

** At the time the CTIAC was created, the "Concrete Laboratory" was called "Concrete Division;" later it was called "Concrete Laboratory;" now it is part of the "Structures Laboratory."*

action taken, response made, difficulties encountered, time expended, and elapsed time required to complete the necessary action. The report on this project was published in December 1972, entitled "Concrete Technology Information Analysis Center, Evaluation of Pilot Study," WES Miscellaneous Paper C-72-24, TISA Project Report No. 41 (Project 02-07), and CTIAC Report No. 11.

OBJECTIVE AND APPROACH

The technical objective of the CTIAC is: "To collect, analyze, evaluate, and disseminate information in the broad field of concrete technology and perform all functions of a DoD Information Analysis Center as prescribed in AR 70-22."

The approach is stated to be: "Information is collected; the 'International Exchange of Information Scheme' in a concrete technology is participated in; queries are responded to; reports covering the state-of-the-art and annotated bibliographies are prepared and distributed; reference searches and loads are provided."

DATA BASE

The CTIAC is supported by the Library Branch, Technical Information Center, WES, which contains approximately 200,000 items including books, periodicals, reports, pamphlets, standards, microforms, unpublished matter, and other data. The Library is a bibliographic center, containing a dozen catalogs of other libraries in related fields of interest, capable of supporting research on the doctoral level. Library resources are supplemented by services of the Defense Technical Information Center (DTIC); the installation of a Defense RDT&E On-Line computer terminal in the Library has greatly facilitated the flow of information between DTIC and WES.

PROGRAM

Despite a deliberate decision not to publicize widely the existence of the CTIAC, the volume of inquiries and requests for service continues to increase. A major element in CTIAC plans must therefore be to be prepared to provide answers to inquiries and services to users as requested. In providing services it is often necessary to provide to the inquirer, directly from the CTIAC, copies of one or more relevant bibliographies or summaries of the state-of-the-art. To date, with very few exceptions, these documents have been produced and published using other funds. It is planned, as a method of increasing the efficiency of response of the CTIAC, to produce, publish, and reprint such of these reports as may be necessary to meet user requirements, as resources permit. Many users will still need to be referred to DTIC or NTIS because of unavailability here of copies of relevant documents in print, a condition that often precludes providing the required information in a timely manner. In some cases this situation is mitigated by the use of library loan copies of relevant documents. The data base will be reviewed and steps taken to enhance its capabilities by recommending additional purchases, subscriptions, and exchanges. Reference searches will continue to be provided in cooperation with the Library Branch, Technical Information Center. Plans for automated search and retrieval will be developed jointly with other WES TIAC's in cooperation with the WES Technical Information Center.

INTERNATIONAL EXCHANGE OF INFORMATION

During the period 2-6 March 1970, the Director, CTIAC, was a member of a delegation of six individuals from the United States, and the only representative of the U.S. Government, at the Conference on International Exchange of Information on Cement and Concrete Research, held at the Institution of Civil Engineers, London, England. There were 30 registrants from 18 organizations in 10 countries. The host was the Cement and Concrete Association (C&CA) in conjunction with the Concrete Society. U.S. participation was coordinated by the ACI. A full report was distributed by the ACI in April 1971.* As a result of informal agreement at this conference, the CTIAC continues to receive a very substantial amount of useful information from the other organizations that participated.

For further information, contact: Bryant Mather, Director, CTIAC, Chief, Structures Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180.

** American Concrete Institute, Conference on International Exchange of Information on Cement and Concrete Research, London, England, March 2-6, 1970, Detroit, Michigan.*

ABSTRACTS FROM THE CURRENT LITERATURE

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ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 2104, 2124, 2239, 2253, 2280)

81-2047

Noise Caused by the Interaction of a Rotor with Anisotropic Turbulence

E.J. Kerschen and P.R. Gliebe

General Electric Corporate Res. and Dev., Schenectady, NY, AIAA J., 19 (6), pp 717-723 (June 1981) 7 figs, 1 table, 23 refs

Key Words: Rotors, Fan noise, Turbulence, Aircraft noise, Engine noise

An analytical model of fan noise caused by inflow turbulence, a generalization of earlier work by Mani, is presented. Axisymmetric turbulence theory is used to develop a statistical representation of the inflow turbulence valid for a wide range of turbulence properties. Both the dipole source due to rotor blade unsteady forces and the quadrupole source resulting from the interaction of the turbulence with the rotor potential field are considered. The effects of variations in turbulence properties and fan operating conditions are evaluated.

81-2048

A Direct Integration Technique for the Transient Analysis of Rotating Shafts

F.H. Chu and W.D. Pilkey

J.J. McMullen Assoc., Inc., One World Trade Ctr., Suite 3047, New York, NY 10048, J. Mech. Des., Trans. ASME, 103 (4), pp 244-248 (Jan1981) 2 figs, 12 refs

Key Words: Shafts (machine elements), Rotors, Bearings, Structural members, Transfer matrix methods

The Continuous Space Discrete Time Riccati Transfer Matrix Method is a new direct integration technique for transient analysis of structural members. This method is applied to rotating shafts with bearing systems containing masses. Numerical results are given for a rotor with isotropic bearings.

81-2049

Experiments on the Vibration Characteristics of a Rotor with Flexible, Damped Support

L.-T. Yan and Q.-H. Li

Beijing Aeronautical Inst., Beijing, Peoples Rep. of China, J. Engr. Power, Trans. ASME, 103 (1), pp 174-179 (Jan 1981) 11 figs, 2 tables, 5 refs

Key Words: Rotors, Flexible foundations, Squeeze-film dampers, Damping effects, Experimental test data, Aircraft engines

Experiments were performed on a model rotor test rig with a disk located at the mid-span and a squeeze film damper and/or flexible support at one end and a rigid support at the other end. The damping effects of the flexible support and stress variation of the support itself have been tested. Emphasis was placed on the steady state characteristics and the damping effects of the flexible supports and dampers with different radial clearances under various levels of rotor unbalance. The dampers are without end seals and oil grooves. Comparative tests of the damping effects of the flexible, damped support were done during passing through the first and second critical speeds. Simulating tests of the vibration of the bearing housing excited by nonrotor exciting sources have been carried out and the damping effects of the oil film dampers on this type of vibrations were examined.

81-2050

Influence of Acceleration on the Critical Speed of a Jeffcott Rotor

H.L. Hassenpflug, R.D. Flack, and E.J. Gunter

Dept. of Mech. and Aerospace Engrg., School of Applied Science and Engrg., Univ. of Virginia, Charlottesville, VA 22901, J. Engr. Power, Trans. ASME, 103 (1), pp 108-113 (Jan 1981) 12 figs, 5 refs

Key Words: Rotors, Critical speeds, Acceleration effects, Damping effects, Unbalanced mass response, Parameter identification technique

The effects of angular acceleration on a Jeffcott rotor have been examined both theoretically and experimentally. The equations of motion were solved via numerical integration. The rotor's response to unbalance was predicted for a number of cases of acceleration and damping. Both amplitude and phase responses were studied. In addition, techniques were developed for identifying system damping from data taken during accelerated runs. The results of the analysis indicate that for high acceleration rates the amplitude response at the critical speed may be reduced by a factor of four or more. Experimentally, a small lightly damped rotor was run for several acceleration rates. Also, a beat frequency was observed both theoretically and experimentally after the rotor had passed through the critical speed.

81-2051

Nature of Inlet Turbulence and Strut Flow Disturbances and Their Effect on Turbomachinery Rotor Noise

R. Trunzo, B. Lakshminarayana, and D.E. Thompson

Applied Research Lab., Pennsylvania State Univ., University Park, PA 16802, J. Sound Vib., 76 (2), pp 233-259 (May 22, 1981) 23 figs, 3 tables, 15 refs

Key Words: Turbomachinery, Rotors, Noise generation, Fluid-induced excitation, Turbulence

Results of an investigation in which turbomachinery rotor sound spectra were correlated with aerodynamic measurements of the inlet turbulence, strut wake, and vortex flow strengths are reported. Aerodynamic measurements included mean velocity profiles, turbulence intensity, and axial length scales. Inlet turbulence data indicate that the major effect of flow contraction appears to be the elongation of turbulent eddies. Eddies of this size dominate the blade passing frequency (BPF) tones. Decreasing eddy size by use of a grid revealed vortex flow strength to be the second major sound source. A doubling of vortex flow strength produced a 6 dB increase in the SPL of the first BPF. The sound pressure level showed less than a 2 dB change with doubling of strut wake turbulence intensity or velocity defect. A discussion of the relative importance of various sources of noise due to flow non-uniformities at the inlet is given.

81-2052

Determining the Hydraulic Lateral Force of Pump-Turbines

E. Kramer

Technische Hochschule, Petersenstr 30, 6100 Darmstadt, Fed. Rep. Germany, Water Power Dam Const., pp 50-54 (Jan 1981) 5 figs, 6 refs

Key Words: Turbines, Pumps, Force coefficients, Vibratory techniques

High-performance pump-turbines are subjected to heavy hydraulic lateral forces during transient operating conditions. This article describes a method permitting calculation of the maximum lateral force on the basis of the vibrations measured at any point on the machine.

81-2053

Critical Speeds of Multi-Throw Crankshafts Using Spatial Line Element Method

C. Bagci and D.R. Falconer

Dept. of Mech. Engrg., Tennessee Technological Univ., Cookeville, TN, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 25-41 (May 1981) 9 figs, 1 table, 17 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Critical speeds, Crankshafts, Finite element technique

A finite element method for the determination of the critical speeds of multi-throw crankshafts is presented. A crankshaft is considered as a three-dimensional dynamic system and throws in their actual geometries spaced at some angles relative to each other and subjected to flexural, axial, and torsional deformations. Both regular and irregular elements are used. Masses and rotary inertias are lumped to the joint freedoms chosen as generalized coordinates, using either discrete element mass matrix or the consistent element mass matrix plus the discrete external load mass matrix, depending on the model used. An experimental unbalanced crankshaft having three throws of different sizes, supported by four bearings, connected to a variable speed drive by a flexible coupling, and carrying three external load disks is designed, tested, and results are compared with those of analytical finite element solutions for different models, including those considering rotary inertias, flexible bearings, and equivalent pure torsional straight shaft models, showing the method of the article to be a very efficient tool for the dynamic design of industrial crankshafts.

81-2054

An Improvement to Shaikh's Method for the Torsional Vibration Analysis of Branched Systems

B. Dawson and M. Davies

Polytechnic of Central London, London, England, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 1-10 (May 1981) 5 figs, 3 tables, 5 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Branched systems, Torsional vibration, Natural frequencies, Iteration, Mechanical drives, Marine engines

A globally convergent iteration technique developed by the authors for application to residual function value vibration analysis methods is developed as an extension to the method proposed by Shaikh. This yields a fully automatic, efficient and foolproof method irrespective of the natural frequency distribution or frequency range of the problems. The iteration formula in the extended method requires the first and second derivatives of the residual determinant as well as the determinant itself and the method of derivation of these derivatives via both a matrix transfer and Holzer procedure is presented. Illustrative examples of the application of the extended method to the solution of the torsional natural frequencies of marine geared drive systems are presented which demonstrate the power and efficiency of the extended method, irrespective of the natural frequency distribution or the frequency range of the problem.

RECIPROCATING MACHINES

(Also see Nos. 2217, 2252)

81-2055

An Attempt of Noise Reduction to a Small Two-Stroke Cycle Crankcase-Scavenged Engine (Versuche zur Geräuschminderung an einem Zweitakt-Kurbelkammermotor)

K. Groth and N. Kania

Institut f. Kolbenmaschienen der Universität, Welfengarten 1A, D-3000 Hannover 1, Germany, MTZ Motortech. Z., 42 (5), pp 201-203 (May 1981) 5 figs, 1 table, 8 refs

(In German)

Key Words: Engine noise, Noise reduction, Saws

One of the dominant noise sources of small two-stroke-cycle and crankcase scavenged engines (port covered and uncovered by the working piston) represents the intake noise. The opening and closing of the port of these engines which are used to drive chainsaws causes intake oscillations of large amplitudes. These are an important part of the total noise with regard to the point of measurement at the ear of the saw operator. By using a special intake port shape and the advancing of the port opening the gradient of the cross section course is reduced. The reduction of the total noise level is about 2 . . . 4 dB(A) as a function of the speed at full load while the delivery rate and the output remain constant.

81-2056

Noise Reduction of Chain Saws Driven by Two-Stroke Engines (Gesamtschallpegelreduzierung an Motorkettensägen)

N. Kania

MTZ Motortech. Z., 42 (5), pp 193-200 (May 1981) 10 figs, 1 table, 12 refs

(In German)

Key Words: Saws, Noise reduction, Silencers, Engine noise

The total noise level of modern chain-saws driven by two-stroke engines is about 102-110 dB(A) at full load. This level represents a considerable burden for the staff. The total noise has been divided into the most important sources: exhaust-, intake- and mechanical noise. The exhaust noise represents the most dominant excitation but also the intake noise gets more importance because of its directional characteristic with regard to the point of measurement at the ear of the saw operator.

81-2057

Investigation of the Gas Vibrations of Rotary Piston Compressors and of Their Pressure Lines (Untersuchungen über Gasschwingungen in einem Drehkolbenverdichter und dessen Druckleitung)

K. Graunke

Hannover, Germany, Fortschritt-Berichte, VDI Z., Ser. 7, No. 58 (1981), 206 pp, 81 figs. Summarized in VDI Z., 123 (5), p 175 (Mar 1981), Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Düsseldorf 1, Germany, Price 106-DM

Key Words: Reciprocating engines, Engine noise

In order to reduce the noise in rotary piston compressors by structural means, the noise mechanisms must be known. For that an exact knowledge of the generation, type and the amount of fluctuation of the unstationary gas flow in the machinery is required. The report describes measurement techniques and a computer program for the investigation of these unstationary processes.

METAL WORKING AND FORMING

81-2058

Dynamic Behavior of Lathe Spindles with Elastic Supports Including Damping by Finite Element Analysis

A.M. Sharan, T.S. Sankar, and S. Sankar

Dept. of Mech. Engrg., Concordia Univ., Montreal, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 83-96 (May 1981) 11 figs, 2 tables, 10 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Machine tools, Lathes, Spindles, Damping, Natural frequencies, Mode shapes, Finite element technique

This paper presents the free-vibration behavior of a lathe spindle-workpiece system using finite element analysis. The investigation is carried out in three parts which are: the classification of the end condition at the running center, the determination of the undamped natural frequencies and the corresponding mode shapes, and the effect of bearing stiffness on the natural frequencies as well as the mode shapes. The theoretically computed natural frequencies are compared with the experimentally obtained frequencies. The end condition at the running center is classified based on the sum of the squares of the residues between the experimental and the theoretically obtained natural frequencies. The undamped mode shapes are explained in terms of the interacting play between the inertia forces, the flexural rigidity of the system, and the spring forces.

81-2059

A Feasibility Study of On-Line Identification of Chatter in Turning Operations

K. Eman and S.M. Wu

Dept. of Mech. Engrg., Univ. of Wisconsin, Madison, WI, J. Engr. Indus., Trans. ASME, 102 (4), pp 315-321 (Nov 1980) 3 figs, 2 tables, 9 refs

Key Words: Machine tools, Chatter, Dynamic data system technique, System identification techniques

The Dynamic Data System approach has been used to develop an identification scheme for chatter in turning. The purpose of developing this simplistic scheme was to enable its easy implementation on a microprocessor so that on-line identification could be accomplished. It has been shown that the stochastic models are capable of following the changing parameters of the process. The modal parameters of the dominant modes are determined along with the relative contribution of each mode to total power of the analyzed output signal from the machining process. Based on this information the mode susceptible to chatter is identified and as a simple index of stability the modal damping ratio or equivalently the magnitude of the root of the characteristic equation introduced. The theoretical postulations were confirmed experimentally for three different states of the turning process, namely, stable cutting conditions, transient state when chatter started to develop and finally fully grown chatter vibrations.

81-2060

Quantitative Relationships for Acoustic Emission from Orthogonal Metal Cutting

E. Kannatey-Asibu, Jr. and D.A. Dornfeld

Univ. of California, Berkeley, CA, ASME Paper No. 80-WA/Prod-26

Key Words: Metal working, Acoustic emission

Theoretical relationships have been drawn between acoustic emission (AE) and the metal cutting process parameters by relating the energy content of the AE signal to the plastic work of deformation which generates the emission signals. The RMS value of the emission signal is expressed in terms of the basic cutting parameters.

MATERIALS HANDLING EQUIPMENT

81-2061

Study on Vibratory Feeders: Calculation of Natural Frequency of Bowl-Type Vibratory Feeders

S. Okabe and Y. Yokoyama

Faculty of Engrg., Kanazawa Univ., Kanazawa, Japan, J. Mech. Des., Trans. ASME, 103 (4), pp 249-256 (Jan 1981) 11 figs, 8 refs

Key Words: Vibrators (machinery), Materials handling equipment, Natural frequencies

This paper treats a method of calculating natural frequency of vibratory feeders. In a bowl-type feeder, the deformation of the spring is complicated and the exact calculation of its constant is difficult. Therefore an approximate calculation is presented under some assumptions. The relations between spring constant and spring setting condition are clarified and shown in various diagrams. The equations of natural frequency for the fixed type and the semi-floating type feeder are represented briefly. The vibration direction of bowl-type feeder is also discussed. The theoretical results are confirmed by experimental studies.

STRUCTURAL SYSTEMS

BUILDINGS

(Also see Nos. 2176, 2189)

81-2062

Interpretation of Strong-Motion Earthquake Records Obtained in and/or Near Buildings, Proc. of a Workshop Held at San Francisco, CA on April 1-2, 1980

G.C. Hart, C. Rojahn, and J.T.P. Yao

Dept. of Mechanics and Structures, Univ. of California, Los Angeles, CA, Rept. No. UCLA-ENG-8015, NSF/RA-800384, 137 pp (Apr 1980)
PB81-154726

Key Words: Buildings, Seismic excitation, Measurement techniques, Measuring instrumentation, Data processing, Proceedings

Existing building strong-motion earthquake instrumentation programs are reviewed and summarized. Specific aspects discussed include building instrumentation programs, current strong-motion ground record processing, utilization of strong-motion records in building design, and information obtained from strong-motion records. Procedures for processing and interpreting data from existing programs are documented. New methods are identified to improve data acquisition analysis and interpretation techniques. Recommendations address fundamental policy, specific technical aspects of instrumentation, data processing, and research needs. The report includes extensive references, the workshop program and its participants, and brief written presentations.

81-2063

Vibration of Buildings under Random Wind Loads
E. Safak
Ph.D. Thesis, Univ. of Illinois, 141 pp (1980)
UM 8108648

Key Words: Buildings, Multistory buildings, Wind-induced excitation, Random excitation

Wind and earthquakes are two of the major environmental forces acting on multistory buildings. Since current design practice often leads to slender and flexible buildings, the dynamic effects of the wind are of increasing importance. The purpose of this study was to develop a method for analyzing the three-dimensional dynamic response of buildings subjected to random wind loads.

81-2064

Inelastic Analysis of 3-D Mixed Steel and Reinforced Concrete Seismic Building Systems
F.Y. Cheng
Civil Engrg. Dept., Univ. of Missouri-Rolla, Rolla, MO 65401, Computers Struc., 13 (1-3), pp 189-196 (June 1981) 13 figs, 16 refs

Key Words: Buildings, Reinforced concrete, Steel, Seismic excitation, Computer programs

This paper presents partial results of a project for studying the response behavior of inelastic building systems subjected to the simultaneous input of static loads and multicomponent earthquake motions that can be applied in any direction of the structural plan. The analysis includes the second-order moment resulting from the gravity load and the vertical ground motion.

UNDERGROUND STRUCTURES

81-2065

Dynamic Response of Underground Structures
G.M. Manolis
Ph.D. Thesis, Univ. of Minnesota, 218 pp (1980)
UM 8109465

Key Words: Underground structures, Cavity-containing media, Linings, Cavities

Various models are developed for the determination of the dynamic response of simple underground structures in the state of plain strain. Two basic soil models are employed: continuum mechanics models and discrete models.

HARBORS AND DAMS

81-2066

Random Hydrodynamic Force on Dams from Earthquakes
C.Y. Yang and V. Chiarito
Dept. of Civil Engrg., Univ. of Delaware, 130 Dupont Hall, Newark, DE 19711, ASCE J. Engr. Mech. Div., 107 (1), pp 117-129 (Feb 1981) 4 figs, 5 tables, 13 refs

Key Words: Dams, Hydrodynamic excitation, Random excitation, Earthquake damage, Seismic excitation

A new solution for the hydrodynamic force on dams due to random earthquake accelerations is obtained in terms of nonstationary power spectra and mean square functions. Numerical results and special analytic solutions are obtained and presented in nondimensional forms. The earthquake acceleration is modeled by a stationary white noise with a unit step modulation function. The response spectra are narrowly banded and sharply peaked at resonant frequencies.

81-2067
Reliability of Dams Subjected to Hydrodynamic Forces During Earthquakes
V. Chiarito
Dept. of Civil Engrg., Delaware Univ., Newark, DE, Master's Thesis, Rept. No. W81-01495, OWRT-A-047-DEL(3), 103 pp (June 1981)
PV81-163594

Key Words: Dams, Hydrodynamic excitation, Seismic waves

The assumptions and formulation of the governing wave equation are presented for the dam-reservoir system. The equations for the random hydrodynamic force and moment response are derived in a nondimensional form. Using random vibrations theory reliability functions are formulated for stability criteria concerning sliding and overturning. An application of the final results to Hoopes Dam in Delaware is presented. The safety of the dam-reservoir system is analyzed by a probabilistic approach.

POWER PLANTS

(Also see Nos. 2168, 2172)

81-2068
Modification by Trench Barriers of the Seismic Input to Nuclear Power Plants
B.A. Bolt and H.F. Morrison
Dept. of Engrg. Geoscience, Univ. of California, Berkeley, CA, Rept. No. UCB-ENG-4723, 190 pp (Jan 1981)
NUREG-CR-1777

Key Words: Nuclear power plants, Seismic waves, Seismic barriers

The effect of placing barriers in the travel path of seismic wavefields has been studied using two-dimensional, time-domain finite element programs. The barriers are trenches, either open-air or filled with a material of low shear rigidity (e.g., slurry) and vertical changes in surface relief (scarps). SH and PSV wavefields were studied which propagated parallel to the surface of a model consisting of a single layer overlying a halfspace. Elastic and viscoelastic mediums were considered. Results are in the forms of power spectral ratios which are the spectral energy observed with the barrier divided by the spectral energy without the barrier.

81-2069
Nonlinear Response of a Post-Tensioned Concrete Structure to Static and Dynamic Internal Pressure Loads
T.A. Butler and J.G. Bennett
Los Alamos National Lab., Los Alamos, NM 87545, Computers Struc., 13 (5-6), pp 647-659 (Oct-Dec 1981) 21 figs, 3 tables, 7 refs

Key Words: Nuclear power plants, Containment structures, Finite element technique, Nonlinear response, Computer programs

A nonlinear finite element model of a nuclear power plant containment building was developed to determine its ultimate pressure capability under quasistatic and impulsive dynamic loads. The ADINA finite element computer code was used to develop the model because of its capability to handle concrete cracking and crushing. Results indicate that, even though excessive concrete cracking occurs, failure is ultimately caused by rupture of post-tensioning tendons.

81-2070
Methods for the Seismic Effect Analysis on the Nuclear Power Station Structures
F. Jeanpierre and M. Livolant
Div. d'Etude et de Developpement des Reacteurs, CEA Centre d'Etudes Nucleaires de Saclay, Gifsur-Yvette, France, Linear and Non-linear Calculation of Piping Systems. CONF-800147-1, 40 pp (1980) Conf. held Jan 21, 1980, Paris, France
(In French)
CEA-CONF-5080

Key Words: Nuclear power plants, Nuclear reactors, Containment structures, Seismic response

As a result of the serious secondary effects that uncontrolled destructions could involve in a nuclear reactor, particularly the bursting of containment vessels or the non operation of safety systems such as the automatic drop of rods to halt the chain reaction, the earthquake hazard must be taken into account, in terms of the location of the power station, and the effects of the seism carefully estimated. The purpose of this report is briefly to describe the methods used to this end.

OFF-SHORE STRUCTURES

(Also see No. 2250)

81-2071
Assessment of Linear Spectral Analysis Method for

Offshore Structures via Random Sea Simulation
S. Kao
Mobil Res. and Dev. Corp., Dallas, TX, ASME Paper No. 81-Pet-9

Key Words: Offshore structures, Spectrum analysis, Simulation

With random sea simulation, application of the linear spectral analysis method to offshore structures with moderate drag force has been assessed. Findings indicate overprediction of response for short natural periods and underprediction for very long periods. Tentative corrective measures are recommended.

81-2072
Deterministic Fluid Forces on Structures: A Review
J.W. Leonard, C.J. Garrison, and R.T. Hudspeth
Dept. of Civil Engrg. and Ocean Engrg. Programs, Oregon State Univ., Corvallis, OR 97331, ASCE J. Struc. Div., 107 (6), pp 1041-1057 (June 1981) 53 refs

Key Words: Offshore structures, Fluid-induced excitation, Water waves, Hydrodynamic excitation, Reviews

The deterministic wave- and current-induced hydrodynamic loadings on sea-based structures are reviewed. This state-of-the-art review does not include geotechnical, surface, or installational/operational forces. Wave-induced loadings in both the small member (Morison equation) and large member (diffraction) regimes of wave force computations are reviewed. The selection of appropriate water wave theories and hydrodynamic force coefficients is included. The effects of laboratory facilities on the evaluation of the hydrodynamic force coefficients for periodic flows are also considered.

VEHICLE SYSTEMS

GROUND VEHICLES

81-2073
Techniques for the Investigation of Road Traffic Noise in Regions of Restricted Flow by the Use of Digital Computer Simulation Methods
R.R.K. Jones, D.C. Hothersall, and R.J. Salter
School of Civil and Struc. Engrg., Univ. of Bradford, Bradford BD7 1DP, UK, J. Sound Vib., 75 (3), pp 307-322 (Apr 8, 1981) 8 figs, 4 tables, 11 refs

Key Words: Traffic noise, Noise prediction, Digital techniques, Computer-aided techniques

Computer methods of calculating and predicting the noise from road traffic operating in restricted flow conditions are discussed. A method of calculating the noise from road traffic as a function of the maneuvering parameters by means of a Monte Carlo digital computer simulation model is briefly described.

81-2074
The Influence of Truck Hunting Severity on Freight Car Structures
M.F. Hengel, C. Montgomery, and R.H. Billingsley
Missouri Pacific R.R. Co., St. Louis, MO, J. Engr. Indus., Trans. ASME, 102 (4), pp 322-326 (Nov 1980) 7 figs, 2 refs

Key Words: Trucks, Freight cars, Hunting motion, Wear

This paper describes the results of two field investigations in which truck hunting instability led to either excessive wear or structural degradation. Various means readily available to the industry were then investigated as to their effectiveness in controlling hunting. Results are presented showing that the particular problems encountered were avoided by control of the hunting phenomenon rather than its complete elimination.

81-2075
Tracks-Gravel-Bridge Interaction
G. Müller, D. Jovanović, and P. Haas
Control Data GmbH, Friedrichstasse 9a, 7000 Stuttgart 1, Fed. Rep. Germany, Computers Struc., 13 (5-6), pp 607-611 (Oct-Dec 1981) 7 figs, 2 refs

Key Words: Railroad tracks, Bridges, Girders

For various long valley bridges the interaction between tracks, gravel and bridge girders is investigated. Two load cases are assumed: horizontal forces due to braking and horizontal loading due to temperature difference between tracks and girders. The behavior of gravel is approximated by a nonlinear load-dependent elastic-plastic material law. The aim of the study is to find out a system which is capable to carry the horizontal loads not exceeding a given stress limit in the rails. Compression-only buffers, built in between the girders, have proven to be most effective.

81-2076

A Method for Determining the Effect of Transportation Vibration on Unitized Corrugated Containers

T.J. Urbanik

Forest Products Lab., Forest Service, U.S. Dept. of Agriculture, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 213-224 (May 1981) 5 figs, 1 table, 8 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shipping containers, Containers, Transportation effects

A unitized stack of containers in transit is susceptible to dynamic overloading due to vibrations in the transporting vehicle. The boxes' compressive stiffnesses interact with the content masses to amplify or attenuate the vehicle motions through the height of the column. Modeling a unit load as a multiple-degree-of-freedom vibration system provides a method for evaluating it based on its sensitivity to the frequencies inherent to the transportation environment. This report presents the theoretical analysis of the analog that represents a stack of containers and an example that carries the mathematics through a package design problem. To supplement the manual computations which are too time-consuming for practical packaging design, a computer program – not included herein – is discussed. This program plots the transmissibility in each container over a range in frequencies. An example using the program shows how to interpret the plots and compare the effects of transportation vibration on different unit loads.

81-2077

Shock, Vibration and Fatigue in Transportation Industries

T.V. Seshadri

Principal Engineer, Systems, Fruehauf Corp., Detroit, MI, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 15-22 (May 1981) 7 figs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Fatigue life, Transportation vehicles, Articulated vehicles, Transportation effects

Fatigue failure is the most common form of failure in transportation industries. Design for fatigue loading, taking into account all the variables, is complex. A durability test technique for tractor-trailers is presented. A dynamometer is used which inputs periodic bumps to the vehicle. Even though this technique does not simulate the road loading in real time, it provides an overall view of the adequacy of the design for field loads. Theoretical analysis is performed treating the vehicle as a simple dynamical system. A brief review of fatigue design is included.

81-2078

A Seismic Membrane-Crash-Sensor for the Measuring of Accident-Caused Deceleration in Automobiles (Ein seismischer Membran-Crash-Sensor für die Messung unfallspezifischer Verzögerungen im Kraftfahrzeug)

M.-U. Reissland

Universität GH Siegen, 5270 Gummersbach 1, Am Sandberg 1, Germany, Feinwerk u. Messtechnik, 89 (2), pp 89-97 (Mar 1981) 15 figs, 1 table, 11 refs (In German)

Key Words: Collision research (automotive), Detectors, Seismic detectors

The knowledge of the temporal and local crash development is a precondition for sensing the accident caused automobile deceleration and for the activating of the safety system. This is described, wherein the sensoring is concentrated on most. A slightly moved membrane operates as a seismic transmitter between two printed circuits. These represent the measurable inductance of a bridge circuitry. The formation of the probe as a membrane also permits pressure and force measurement.

SHIPS

(Also see Nos. 2198, 2211, 2247, 2248, 2288)

81-2079

Calculating Responses in Hull Mounted Items of Equipment in Submarines Compared with Measurements Carried Out During Shock Tests

K. Hellqvist

Kockmus AB, Malmö, Sweden, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 111-119

(May 1981) 10 figs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock tests, Submarine hulls, Shipboard equipment response, Underwater explosions

The paper describes a method developed in Sweden for calculating responses of items and outfits mounted in submarines subjected to underwater explosions. The shock form is described by means of the Fourier transform of the acceleration-versus-time graph. Dynamic properties of hull and items are defined by their inertances. The method enables responses of items and outfits to be calculated using the above quantities whilst taking into account the reaction between units and hull structure. The method has been used on results from measurements on a specially designed structure in the 'Steel Mosquito' and the results obtained are presented in this paper.

81-2080

Transient Response Analysis of a Large Radar Antenna

E. Meller, W.A. Loden, and W. Woltornist

Lockheed Palo Alto Research Lab., Palo Alto, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 159-167 (May 1981) 9 figs, 1 table, 7 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spon. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Antennas, Shipboard equipment response, Transient response, Underwater explosions, Shock response, Finite element technique

The approach used in determining the transient response of a large shipboard-mounted radar antenna to shock loading resulting from an underwater explosion is described. The dynamic behavior of the antenna configuration, represented by a finite element model of moderate complexity, was determined through direct time integration, using as the "forcing" function the anticipated motion of the ship platform on which the antenna was mounted. The location in the antenna where the peak stresses occurred was determined by the inspection of the stress results from this transient response analysis, and a refined finite element model of this region was used to compute more accurate stresses.

81-2081

Response of Hydrofoil Strut-Foil Systems After Impact with "Dead-Head" Logs

H. S. Levine and A.P. Misovec

Weidlinger Associates, Menlo Park, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 143-158 (May 1981) 18 figs, 2 tables, 10 refs (51st Symp. Shock Vib. San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Hydrofoil craft, Impact response (mechanical)

Hydrofoils have recently experienced debris strikes from "dead-head" or vertical floating logs. The present study represents an initial step in the prediction of the response of strut-foil systems after such impact, with the eventual application being the design of composite strut-foil systems. In the early stages of the investigation reported upon here, the response of steel foils and struts was studied. A simplified technique to determine the log-foil interaction force is first developed. This is then applied to a beam model of a generic strut-foil system to predict its response. A more sophisticated finite element model is then used to study the early-time strut-foil-log interaction. Basic phenomenology is studied and recommendations for improving the analytical techniques are made.

AIRCRAFT

(Also see Nos. 2047, 2049, 2102, 2235, 2236, 2237, 2253)

81-2082

Finite Element Analysis of Asymmetric, Lateral Natural Vibrations of a Deformable Aeroplane

Z. Dżygadlo and J. Blaszczyk

Polish Academy of Sci., Inst. of Fundamental Technological Res., Warszawa, Poland, J. Tech. Phys., 21 (3), pp 349-366 (1980) 9 refs, 5 figs

Key Words: Aircraft, Natural frequencies, Finite element technique

The deformable parts of an airplane are divided into finite elements, the edges of which are normal to their rigidity axes. Equations of dynamic equilibrium of the deformable structural parts (superelements) of the plane are determined as well as the equations of motion of the rigid parts, constituting dynamic conditions of coupling for the former equations. Lateral vibrations are studied.

81-2083

Airport Planning and the Environmental Impact Process

C.R. Bragdon

S/V, Sound Vib., 15 (12), pp 11-13 (Dec 1980) 5 refs, 3 tables

Key Words: Aircraft noise, Airports

An evaluation of 102 airport land use and noise control studies conducted in the Southeastern United States is presented. The results show that noise is not consistently addressed in the environmental impact studies.

81-2084

Acoustic Environment on the Surface of a Large-Scale Powered Model of a Vectored-Engine-over-the-Wing STOL Configuration

L.L. Shaw and S.Y. Lee

Air Force Wright Aeronautical Labs., Flight Dynamics Lab., Wright Patterson AFB, OH 45433, Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 51, Pt 3, pp 225-235 (May 1981) 19 figs, 1 table, 6 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Aircraft noise, Noise measurement, Experimental test data

This paper presents the results of an acoustic measurement program on a large, powered, highly maneuverable, supersonic STOL fighter model. The model incorporated vectored-engine-over-the-wing (VEO) concept including spanwise blowing to provide lift augmentation. This concept exposes portions of the wing and flap structure to high fluctuating pressure levels. The results show that levels as high as 167 dB exist on the upper surface of the flap. Levels resulting from a prediction method in the literature agreed with the measured values for only very limited conditions.

81-2085

Analysis of the Effects of Explosive Fuel Ignition on an Aircraft Noise Suppressor System

V.R. Miller, E.R. Hotz, and D.L. Brown

Flight Dynamics Lab., Wright-Patterson AFB, OH, Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 51, Pt 2, pp 169-176 (May 1981) 11 figs, 1 table, 6 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Aircraft noise, Noise reduction, Combustion noise

This paper presents the results from a test in which the door acceleration and the pressure environment were measured in an aircraft noise suppressor system, following the delayed ignition of the augmenter fuel of a turbofan engine such that an explosion of this fuel occurred. The system was instrumented with hydrophones, as well as accelerometers and a high temperature microphone. The resulting data were used to define the effects of the augmenter fuel explosion pressure on the noise suppressor system and its components.

81-2086

Analysis of Subcritical Response Measurements from Aircraft Flutter Tests

J.C. Copley

Royal Aircraft Establishment, Farnborough, Hampshire, UK, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 199-204 (May 1981) 4 figs, 1 table, 7 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Aircraft, Flutter, Transfer functions, Fast Fourier transform

This paper describes a method for the analysis of subcritical response measurements obtained during aircraft flutter tests. Suitable forms of input signal, and the derivation of transfer functions using Fast Fourier transforms are discussed. The transfer functions are subsequently analyzed to give frequency and damping estimates. Because the effects of atmospheric turbulence degrade the measurements, and hence the estimated parameters, a method for assessing the magnitude of the accuracy of the estimates is developed. Examples of the application of the analysis method to typical response data are given.

81-2087

Aircraft Response to Operations on Rapidly Repaired Battle Damaged Runways and Taxiways

T.G. Gerardi and L.R. Caldwell

Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 205-211 (May 1981) 13 figs, 8 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Airports, Weapons effects

The objective of this paper is to summarize the Rapid Runway Repair/aircraft response effort. The goals of project

HAVE BOUNCE are to determine the ground loads capabilities of each aircraft. The planned approach for reaching these goals is through computer simulation, flight testing, and subsequent repair criteria development.

MISSILES AND SPACECRAFT

(Also see Nos. 2118, 2238)

81-2088

SPAR Analysis of LDEF Vibration Characteristics

H.H. Edighoffer and J.L. Sewall
NASA Langley Res. Ctr., MS. 230, Hampton, VA 23665, Computers Struc., 13 (4), pp 489-496 (Aug 1981) 16 figs, 2 refs

Key Words: Spacecraft, Vibration response, Finite element technique, Computer programs

This paper presents a structural dynamic modeling of the Long Duration Exposure Facility (LDEF), which is a Space Shuttle payload of passive scientific experiments contained in trays mounted on a large cylindrically shaped structure. Special detailed finite element modeling, using the SPAR system of computer programs was required to obtain good agreement between analytical and test vibrations modes. Experimental trays contributed significantly to overall LDEF stiffnesses, and these contributions were realistically represented for each tray by the stiffness matrix of an equivalent orthotropic panel in the overall LDEF SPAR model. Orthotropic stiffnesses for this panel were obtained from finely detailed statically loaded tray SPAR models in which stiffness coupling was accounted for along with partial relative sliding allowed by the tray clamping attachments. Joint boundary conditions were also significant in the structural dynamic modeling of LDEF, and static data proved valuable in assessing modeling of local end fittings.

81-2089

Spacecraft Modal Testing Using Systematic Multi-Shakers Sine-Dwell Testing Techniques

F.H. Chu, C. Voorhees, W.W. Metzger, and R. Wilding
RCA Astro-Electronics, Princeton, NJ, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 41-58 (May 1981) 11 figs, 2 tables, 2 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Spacecraft, Modal tests

A systematic test procedure is presented for multi-shaker, sine-dwell, modal test of spacecraft. This procedure has been applied to the modal testing of a Defense Meteorological Satellite. Good results were obtained.

81-2090

A Parametric Study of Certain Forcing Functions Related to a Hypersonic Sled

V.A. Tischler
School of Engrg., Air Force Inst. of Tech., Wright-Patterson AFB, OH, Master's Thesis, Rept. No. AFIT/GAE/AA/80D-22, 78 pp (Dec 1980)
AD-A094 736

Key Words: Rocket sleds, Forcing function, Railroad tracks, Surface roughness

The rail roughness profile and the slipper stiffnesses are the important factors in determining the forcing function in the dynamic analysis of high speed rocket sleds. A parametric study involving a variation in the rail roughness profile and the slipper stiffnesses was performed. This study was carried out by interfacing the NASTRAN structural analysis program and a program called SLEDYNE developed for Holloman AFB. Using NASTRAN a free vibration analysis of the elastic sled body was made in order to obtain the natural frequencies and mode shapes. SLEDYNE simulates the sled ride on the rails and computes a set of inertial forces acting on all the mass points of the sled. The response of the sled to this inertial loading was determined by a NASTRAN static analysis. Two rail roughness profiles were considered, both based on the same set of track measurments, and three values of slipper stiffness were used. Response to the parametric study was measured by the total strain energy of the sled and the displacements of the mass points of the sled.

BIOLOGICAL SYSTEMS

HUMAN

(Also see No. 2229)

81-2091

Vibrational Characteristics of the Embalmed Human Femur

T.B. Khalil, D.C. Viano, and L.A. Taber
Biomedical Science Dept., General Motors Res. Labs.,

Warren, MI 48090, J. Sound Vib., 75 (3), pp 417-436 (Apr 8, 1981) 12 figs, 5 tables, 24 refs

Key Words: Bones, Resonant frequencies, Mode shapes

The resonant frequencies and mode shapes of contralateral femurs have been identified by experimental and analytical procedures. Also, the cross-sectional area, centroid, and principal moments of inertia were computed throughout the femur length for both compact and cancellous bone. Generalized nondimensional resonant frequencies were computed based on femur geometry averaged over its length and compared with those predicted by simple beam models. This analysis provided further understanding of the vibrational behavior of the femur.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 2175, 2183, 2209, 2210, 2216)

81-2092

Analysis of Energy-Absorbing Shock Mounts

V.H. Neubert

Pennsylvania State Univ., University Park, PA 16802, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 149-167 (May 1981) 23 figs, 6 tables, 44 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock absorbers, Energy absorption, Shock tests

The behavior of nonlinear energy-absorbing shock mounts or shock snubbers was measured in a standard test machine and in a drop table shock machine. Configurations tested were an aluminum honeycomb and low carbon steel end-loaded tubes, side-loaded tubes and double reverse corrugated metal.

81-2093

A Dynamic Absorber for Gear Systems Operating in Resonance and Instability Regions

M. Benton and A. Seireg

Engr. R&D Div., E.I. DuPont, Wilmington, DE 19898, J. Mech. Des., Trans. ASME, 103 (2), pp 364-371 (Apr 1981) 6 figs, 5 refs

Key Words: Dynamic absorbers, Gear drives, Optimum design, Design techniques

There are many practical situations where resonances and instabilities in pinion-gear systems are difficult to predict in the design stage due to the unreliability of estimating the mesh stiffness and damping parameters. This paper presents a procedure for the design of an optimal dynamic absorber system which can be used in conditions where preliminary analysis shows that high dynamic tooth loads are likely to occur. The optimal parameters for the absorber are given in a generalized form in order to simplify its design for a particular gear system.

81-2094

Nonlinear Analysis of a Mitigating Steel Nose Cone

M.L. Chiesa and M.L. Callabresi

Analytical Mechanics Div. 8121, Sandia Natl. Labs., Livermore, CA 94550, Computers Struc., 13 (1-3), pp 295-301 (June 1981) 12 figs, 1 table, 13 refs

Key Words: Energy absorption, Steel, Weapons systems, Computer programs

The ability of a structure to mitigate energy associated with impacting hard surfaces plays a significant role in the design and survivability of internal components. This paper summarizes the design and analysis of an efficient nose cone for impacting rigid surfaces. A two-dimensional finite element quasi-static model, utilizing large displacement, large strain formulations, contact-impact surfaces and elastic-plastic material models, was used in the design-iteration phase of the study. Results from the analyses agreed with experimentally tested scaled nose cones, thus permitting the design changes which resulted in an efficient structure for axisymmetric loading to be completed in minimal time. A three-dimensional explicit, dynamic, finite element program was used in the evaluation of an asymmetrical static crush. Efforts to model the material property variation with strain rate led to encouraging results and more work will be required in this area.

81-2095

Response of Shock Isolators with Linear and Quadratic Damping

M.S. Hundal

Dept. of Mech. Engrg., Univ. of Vermont, Burlington, VT 05405, J. Sound Vib., 76 (2), pp 273-281 (May 22, 1981) 7 figs, 1 table, 8 refs

Key Words: Shock absorbers, Viscous damping, Quadratic damping, Base excitation

Performance of two types of shock isolators is analyzed with linear damping and with quadratic law damping. Input to the systems is a base acceleration pulse of rectangular shape. It is found that with quadratic damping the optimum damping ratio varies for different pulse durations.

81-2096

Power Flow through Machine Isolators to Resonant and Non-Resonant Beams

R.J. Pinnington and R.G. White

Inst. Sound Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 75 (2), pp 179-197 (Mar 22, 1981) 17 figs, 8 refs

Key Words: Isolators, Vibration isolators, Mechanical impedance

The parameters controlling power transmission from a vibrating machine to the seating structure, via spring-like vibration isolators, are investigated. The low frequency range is considered where the machine moves as a rigid body. It is shown that the finite seating structure can be modeled by an equivalent structure of infinite extent for frequency averaged power transmission calculations. Power transmission to a finite and an infinite beam via a mass and spring in series is measured experimentally and compared with theoretical predictions. The power transmission is measured by two proposed methods; the first involves the real component of the seating impedance, and the second the transfer impedance of the isolator.

81-2097

Experimental Testing of an Energy-Absorbing Base Isolation System

J.M. Kelly, M.S. Skinner, and K.E. Beucke

Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/35, NSF/RA-800297, 73 pp (Oct 1980)

PB81-154072

Key Words: Isolators, Seismic isolation, Foundation excitation, Energy absorption, Elastomers, Steel, Seismic excitation, Experimental test data

The results of an experimental study of an aseismic base isolation system are described in this report. Commercially produced natural rubber bearings and tapered steel energy-absorbing devices are the primary components of the base isolation system.

81-2098

Experimental Testing of a Friction Damped Aseismic Base Isolation System with Fail-Safe Characteristics

J.M. Kelly, K.E. Beucke, and M.S. Skinner

Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/18, NSF/RA-800292, 62 pp (July 1980)

PB81-148595

Key Words: Isolators, Seismic isolation, Foundation excitation, Coulomb friction, Elastomers, Seismic excitation, Experimental test data

An experimental study of a Coulomb friction damped aseismic base isolation system with fail-safe characteristics is described in this report. The base isolation system utilized commercially made natural rubber bearings and a skid system which comes into operation at preset levels of relative horizontal displacement between the structure and the foundations. The fail-safe skid provides hysteretic damping and prevents failure of the isolation system in the event of displacements larger than those assumed in the original design.

TIRES AND WHEELS

81-2099

Investigation into the Influence of Dynamic Forces on the Tribological Behavior of Bodies in Rolling/Sliding Contact with Particular Regard to Surface Corrugations

H. Krause and T. Senuma

Wear of Materials Dept., Technical Univ. of Aachen, W. Germany, J. Lubric. Tech., Trans. ASME, 103 (1), pp 26-34 (Jan 1981) 15 figs, 1 table, 17 refs

Key Words: Rolling friction, Dynamic response, Interaction: rail-wheel, Wheels

The influence of the action of a dynamic force on the tribological behavior of bodies in rolling/sliding contact without lubrication was examined both experimentally and theoretically. The tests showed that the coefficient of traction and the wear both decrease as the amplitude of the dynamic normal force increases. An attempt was made to explain this phenomenon with the aid of a torsional oscillation model.

BLADES

(Also see No. 2240)

81-2100

On Nonlinear Response of Multiple Blade Systems

A. Muszynska, D.I.G. Jones, T. Lagnese, and L. Whitford

Univ. of Dayton Res. Inst., Dayton, OH, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 89-110 (May 1981) 33 figs, 3 tables, 35 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Blades, Compressor blades, Turbine blades, Harmonic excitation

In the first part of this paper, modal and discrete models are examined from the point of view of predicting the dynamic response of a single jet engine turbine or compressor blade to harmonic excitation by an external force and with restraint provided by a dry friction link to ground. Experimental identification of parameters in the modal and discrete models is discussed. The discrete model is then used as a basis to characterize the nonlinear response of a set of several blades connected at their roots to a rigid disk, and having dry friction coupling from blade-to-blade and from blade-to-ground. The nonlinear differential equations of motion of the system are transformed into a set of nonlinear algebraic equations, which are solved numerically using an iterative method. The results, which are given in terms of amplitudes and phase angles of the response, illustrate several effects including blade mistuning, magnitude and distribution of excitation forces, and phase differences between exciting forces on adjacent blades. Two general types of conclusions may be drawn so far, concerning the influence of dry friction between blades. One concerns the effect of dry friction in reducing response amplitudes (damping effect) and the other concerns effects of blade mistuning (effects of blade-to-blade coupling). These conclusions will be discussed in the paper.

81-2101

Coupled Bending-Torsion Flutter in a Supersonic Cascade

O. Bendiksen and P. Friedmann

Univ. of Southern California, Los Angeles, CA, AIAA J., 19 (6), pp 774-781 (June 1981) 9 figs, 1 table, 22 refs

Key Words: Rotors, Blades, Cascades, Flutter, Coupled response, Flexural response, Torsional response

An investigation of the effects of bending-torsion interaction on the flutter boundaries of a supersonic cascade is presented. The analysis is based on a computationally efficient solution of the unsteady supersonic flow using a dual integral equation formulation. Results indicate that bending-torsion coupling has a significant effect on the flutter boundaries, which agrees with results obtained previously by the authors for incompressible flow. Large variations in the critical interblade phase angle were sometimes observed. The results also indicate a potential instability in the bending mode even in the absence of strong shocks.

81-2102

Finite Element Analysis of Self-Excited Vibrations of Helicopter Rotor Blades

Z. Dzygadlo and W. Sobieraj

J. Tech. Phys., 21 (4), pp 489-504 (1980) 14 figs, 7 refs

Key Words: Blades, Propeller blades, Helicopters, Self-excited vibrations, Flutter, Finite element technique

The present paper is concerned with a method for numerical analysis of self-excited vibrations of a helicopter rotor blade, the determination of the critical flutter parameters being included. The rotor blade is discretized in one dimension by introducing appropriate finite elements. The case under consideration is that of a helicopter in hovering, material damping and aerodynamic forces being taken into account. It is assumed that the geometric parameters of the blade, its moments of inertia and rigidities and also the aerodynamic forces and moments may vary linearly along the elements, while at the edges of the elements there may occur finite jumps of the value of these parameters, which enables modeling of blades with various distributions of parameters, such as are encountered in practice.

81-2103

Coupled Bending-Torsion Vibrations of Rotating Blades on Asymmetric Aerofoil Cross Section with Allowance for Shear Deflection and Rotary Inertia by Use of the Reissner Method

K.B. Subrahmanyam, S.V. Kulkarni, and J.S. Rao

Dept. of Mech. Engrg., Regional Engrg. College, Kurukshetra-132 119, India, J. Sound Vib., 75 (1), pp 17-36 (Mar 8, 1981) 4 figs, 5 tables, 22 refs

Key Words: Blades, Turbomachinery blades, Airfoils, Flexural vibration, Torsional vibration, Coupled response, Transverse shear deformation effects, Rotatory inertia effects, Reissner method

Theoretical natural frequencies and modal shapes of the first five modes of vibration are presented for a rotating blade of asymmetric aerofoil cross section, with allowance for shear deflection and rotary inertia. Frequency equations for a rotating blade with asymmetry in one plane are developed by using the Ritz process, in two ways: namely, by proceeding according to the Reissner method and according to the classical potential energy method. In both cases shape functions for the bending moment, shearing force, twisting moment, bending slope, elastic twist and deflection are developed in series form. The results obtained are compared with those existing in the literature; it is found that the Reissner method approach yields more rapid convergence than does the classical potential energy method.

BEARINGS

81-2104

Nonlinear Effect of Plain Bearings on Rotor Vibrations (Über den nichtlinearen Einfluss von Gleitlagern auf die Schwingungen von Rotoren)

H.-J. Merker

Fortschritt-Berichte VDI-Z, Series 11, No. 40, 180 pp (1981) 100 figs, 3 tables, 36 refs. Avail: VDI Verlag GmbH, Postfach 1139, 4000 Düsseldorf 1, Germany

(In German)

Key Words: Bearings, Rotors

The dynamic behavior of rotors in plain bearings as influenced by nonlinear forces is reported. For small excitations the forces are linearized around an equilibrium condition and are substituted by four spring and four damping constants. The effects of the bearing on the vibrations of the rotor and on its stability are shown and discussed by means of simple rotor models with various types of bearings.

81-2105

Theoretical and Experimental Determination of Damping in Radial Ball Bearings without Clearance (Theoretische und experimentelle Bestimmung der Dämpfung spielfreier Radialwälzlager)

K.J. Klumpers

Laboratorium f. Werkzeugmaschinen und Betriebslehre, Rheinisch-Westfalische Technische Hochschule Aachen, Germany, Fortschritt-Berichte der VDI-Z, Series 1, No. 74, 124 pp (1980) 54 figs. Summarized in VDI-Z, 123 (5), pp 174-175 (Feb 1981). Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Düsseldorf 1, Germany. Price 25,20 DM

(In German)

Key Words: Bearings, Cylindrical bearings, Ball bearings, Damping coefficients, Measurement techniques

Damping characteristics of grooved ball bearings and cylindrical roller bearings without clearance were determined experimentally on a specially built test stand. The rotor-bearing system was cyclically excited by a specially built electromagnetic exciter at the resonant frequencies of vibration, so that the bearing was subjected only to radial deflections. The logarithmic decrement of decay is calculated by means of the method of linear regression from the decay curve recorded on a Fast Fourier Analyzer. From the log decrement the damping of rotor-bearing system is obtained. The experimental results were compared to theoretical results, which were based on the theory of squeeze film damping.

81-2106

Centrifugal Effects in Thrust Bearings and Seals under Laminar Conditions

O. Pinkus and J.W. Lund

Dept. of Machine Elements, Technical Univ. of Denmark, Lyngby, Denmark, J. Lubric. Tech., Trans. ASME, 103 (1), pp 126-136 (Jan 1981) 12 figs, 4 tables, 5 refs

Key Words: Bearings, Thrust bearings, Seals, Gyroscopic effects

An analysis is conducted and solutions are provided for the effect of centrifugal forces on the hydrodynamics of high-speed thrust bearings and seals. First, a scrutiny of the individual inertia terms of the Navier-Stokes equations delineates the circumstances under which the centrifugal term becomes the dominant component. A Reynolds equation incorporating centrifugal forces is then derived for finite sectorial configurations operating under incompressible laminar conditions. Thermal effects are included. The equation is solved by finite difference methods. The results show that at the upper limits of laminar operation centrifugal forces reduce considerably the load capacity and alter the

pattern of lubricant flow. As a result, at sufficiently high velocities the inflow of lubricant at the inner radius of a sectorial configuration may bring about the scavenging of lubricant from wide portions of the bearing surface, producing a form of thrust bearing cavitation. Design features which would reduce the negative consequences of centrifugal action are outlined, including the introduction of radial tapers.

81-2107

High Speed Testing of the Hollow Roller Bearing

W.L. Bowen and T.W. Murphy, Jr.
Torrington Co., Torrington, CT 06790, J. Lubric. Tech., Trans. ASME, 103 (1), pp 1-5 (Jan 1981) 10 figs, 4 tables, 8 refs

Key Words: Bearings, Roller bearings, Test equipment and instrumentation, Fatigue life

This bearing with its preloaded, hollow rollers has the qualities required for high speed operation. Roller hollowness improves cooling ability and its lighter weight reduces the centrifugal force against the raceway. Preloading between inner and outer races for 360 deg insures good roller guidance and minimizes roller skidding. However, the problems of operating a full complement of rollers at very high speeds were unknown. Also, limitations caused by roller bending fatigue needed investigation. To answer these questions, a high speed test machine was constructed and a hollow roller test bearing was designed for operation at 3 million DN. This paper describes the construction of a high speed test cell and subsequent testing of a full complement, preloaded, 115 mm hollow roller bearing. The results verified several advantages regarding roller stability and antiskidding qualities as well as demonstrating a unique fail-safe condition.

81-2108

Measured Characteristics of a Journal Bearing Oil Film

D.W. Parkins
Dept. for Design of Machine Systems, Cranfield Inst. of Tech., Cranfield, UK, J. Lubric. Tech., Trans. ASME, 103 (1), pp 120-125 (Jan 1981) 10 figs, 5 refs

Key Words: Bearings, Journal bearings, Flexibility coefficients, Oil film, Lubrication

This paper presents the results obtained from two experimental methods of measuring the nonlinear characteristics of the eight coefficients which specify the lateral flexibility of a hydrodynamic journal bearing. Measured coefficients are given for both positive and negative discursion of the relevant journal center velocity or displacement from the static equilibrium position which occupied a range of eccentricity ratios. Coefficients are expressed in terms of a "zero" value and linear gradient. No difference was established between displacement coefficients deduced from the two experimental techniques.

81-2109

Hydrodynamic Aspects of Fatigue in Plain Journal Bearings

F.A. Martin, D.R. Garner, and D.R. Adams
Design Techniques Section, Glacier Metal Co., Ltd., Middlesex, UK, J. Lubric. Tech., Trans. ASME, 103 (1), pp 150-156 (Jan 1981) 15 figs, 3 tables, 8 refs

Key Words: Bearings, Plain bearings, Journal bearings, Fatigue life

The fatigue resistance of different bearing materials is usually given an "order of merit" in terms of specific load on the bearing. The bearing material cannot directly sense the applied specific load, since it is the hydrodynamic oil film pressures which directly create the stresses in the lining; both pressures and stresses need to be examined to see if a more meaningful criterion for fatigue can be found. As a first step in this study the experimental fatigue work carried out by Gyde at the University of Denmark was examined and compared with trends in peak specific load, hydrodynamic characteristics, and bearing lining stresses. It has been shown that peak specific load and peak hydrodynamic pressure are not in themselves realistic parameters, but that pressure variation on a bearing element, perhaps including some rapidly forming negative pressures, could be a significant term.

81-2110

Dynamic Analysis of a Cantilever-Mounted Gas-Lubricated Thrust Bearing

I. Etsion and I. Green
Dept. of Mech. Engrg., Technion, Haifa, Israel, J. Lubric. Tech., Trans. ASME, 103 (1), pp 157-163 (Jan 1981) 6 figs, 2 tables, 11 refs

Key Words: Bearings, Thrust bearings, Lubrication, Stiffness coefficients, Damping coefficients

The dynamic stability of a cantilever-mounted gas-lubricated thrust bearing is analyzed using the step-jump approach. The

solution is based on linearization of the equations of motion assuming small perturbation about an equilibrium position. Stiffness and damping of the lubricating film are expressed analytically in terms of Laguerre coefficients, thus enabling a parametric investigation of the bearing. The general theory is used to examine an actual bearing design. It is found that the theoretical results agree with existing experimental data, in that, both show that the bearing is unstable at the design point and becomes more stable as speed decreases.

GEARS

(Also see Nos. 2093, 2251)

81-2111

Friction between High Speed Gear Coupling Teeth

M.M. Calistrat
Mechanical Section, Res. and Dev. Dept., Engineered Metal Products Group, Koppers Co., Inc., Baltimore, MD 21203, J. Mech. Des., Trans. ASME, 103 (4), pp 54-60 (Jan 1981) 10 figs, 3 refs

Key Words: Gears, Gear teeth, Friction

Under misalignment, the teeth of a coupling hub and sleeve slide over each other axially. This motion and the torque transmission generate friction forces. Although laboratory measurements indicated that the friction coefficients are very low, many a thrust bearing failure was blamed on coupling "lock-up." This paper discusses the results obtained from an exhaustive test program in which the friction forces were measured as a function of many variables, including torque, axial velocity, misalignment and lubrication. Friction coefficients as large as .16 were computed when the coupling operated under adverse conditions. Lubrication proved to have the largest influence on the magnitude of the friction coefficients.

81-2112

Simulation of Hertzian Contacts Found in Spur Gears with a High Performance Disk Machine

L. Flamand, D. Berthe, and M. Godet
Laboratoire de Méchanique des Contacts, Institut National des Sciences Appliquées de Lyon, Cedex, France, J. Mech. Des., Trans. ASME, 103 (4), pp 204-209 (Jan 1981) 1 fig, 4 tables, 25 refs

Key Words: Gears, Spur gears, Herzian contact, Simulation, Disks (shapes)

A high performance disk machine capable of simulating both radii of curvature, rolling and sliding speeds of spur gears was built. The simulation program was conducted using both a gear rig and a disk machine. The point chosen for simulation is situated just below the pitch circle. The geometric and dynamic conditions at that point were reproduced. The damage observed in both cases for three different metallurgies and one loading program is presented.

81-2113

A Numerical Solution to the Dynamic Load, Film Thickness, and Surface Temperatures in Spur Gears, Part 1: Analysis

K.L. Wang and H.S. Cheng
A/E Engrg. Ctr., International Harvester Co., Hinsdale, IL 60521, J. Mech. Des., Trans. ASME, 103 (4), pp 177-187 (Jan 1981) 11 figs, 1 table, 29 refs

Key Words: Gears, Spur gears, Dynamic response, Lubrication, Numerical analysis

The present paper is primarily concerned with developing a numerical solution to predict the minimum film thickness, the bulk surface temperature, and the total contact temperature in spur gear teeth contacts. The analysis of transient film thickness and temperature along the line of action is based on some more recent theories on the film thickness and traction in EHD contacts. In addition, the paper also includes, in the first part, an analysis for determining the dynamic load for gears having a contact ratio between one and two.

81-2114

A Numerical Solution to the Dynamic Load, Film Thickness, and Surface Temperatures in Spur Gears, Part II: Results

K.L. Wang and H.S. Cheng
A/E Engrg., Ctr., International Harvester Co., Hinsdale, IL 70521, J. Mech. Des., Trans. ASME, 103 (4), pp 188-194 (Jan 1981) 16 figs, 1 table, 6 refs

Key Words: Gears, Spur gears, Dynamic response, Lubrication, Numerical analysis

The paper concerns the lubrication performance, the distribution of bulk equilibrium temperature, film thickness, and flash temperature along the contacting path for gears operating at speeds below or above the resonance. Plots of the minimum film thickness and the maximum total flash temperature as functions of face width, outside radius, and diametral pitch are given.

FASTENERS

81-2115

A Sensitivity Analysis of the Effects of Interconnection Joint Size, Flexibility, and Inertia on the Natural Frequencies of Timoshenko Frames

I. Yaghmai and D.A. Frohrib

Dept. of Mech. Engrg., Sharif Univ. of Tech., Tehran, Iran, J. Sound Vib., 75 (3), pp 329-346 (Apr 8, 1981) 11 figs, 3 tables, 35 refs

Key Words: Joints (junctions), Framed structures, Beams - Columns, Natural frequencies, Mode shapes, Timoshenko theory

The free vibrations of frame structures are influenced by the geometry, stiffness, and inertia of interconnection joints. The effects of generalized joint properties on the natural frequencies and mode shapes are studied for a wide range of natural frequencies by modeling the structure as a Timoshenko continuous system with discretized joints. Dynamic slope-deflection equations are used in the analysis, adapted to the boundary conditions imposed by joints with axial length, axial and rotary stiffness, and inertia. Beam/column axial deformation is also included. Frequency curves are presented for a wide range of beam/column and joint properties to establish the relative importance of model parameters on system free vibrations.

VALVES

81-2116

Surge-Damping Vacuum Valve

J.C. Bullock and B.E. Kelly

Dept. of Energy, Washington, DC, US Patent No. 4,195,664, 4 pp (Apr 1, 1980)

Key Words: Valves, Fluid-induced excitation, Dampers

A valve having a mechanism for damping out flow surges in a vacuum system is described which utilizes a slotted spring-loaded disk positioned adjacent the valve's vacuum port. Under flow surge conditions, the differential pressure forces the disk into sealing engagement with the vacuum port, thereby restricting the flow path to the slots in the disk damping out the flow surge.

SEALS

81-2117

Advances in Labyrinth Seal Aeroelastic Instability Prediction and Prevention

D.R. Abbott

Advanced Mechanical Design, Aircraft Engine Group, General Electric Co., Lynn, MA 01910, J. Engr. Power, Trans. ASME, 103 (2), pp 308-312 (Apr 1981) 8 figs, 5 refs

Key Words: Seals, Aircraft engines, Fatigue life, Aerodynamic loads

Fatigue cracking of an aircraft engine labyrinth seal occurred during pre-flight factory testing. Testing in a static rig revealed that the seal could be aeroelastically excited by the labyrinth leakage air flow. An earlier analytical model used for stability analysis was extended to account for the effect of acoustic natural frequency on the aeroelastic stability. The new model predicted that the ratio of acoustic and mechanical natural frequencies was of vital importance in determining if the nature of the pressure fluctuations within the labyrinth seal teeth provided either positive or negative aerodynamic damping to the seal. The analytical results were verified by further rig testing and also by correlation with test results for several other seals tested as part of a labyrinth seal technology program. A mechanical friction damper sleeve was designed to suppress the aeroelastic instability. The damper sleeve was tested in a rotating rig to evaluate its damping characteristics.

81-2118

Lateral Dynamics of C4 Missile

F.H. Wolff

Westinghouse R&D Ctr., Pittsburgh, PA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 189-198 (May 1981) 16 figs, 3 tables, 3 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Seals, Missile launchers, Missile launching

A planar model of the C4 missile involving nonlinear force-deflection characteristics for the seals and pads was developed. Rigid body equations of motion based on small angle motion were solved to calculate the lateral motion of the missile during launch. After matching the calculated results to a PS-80 test record, variations in seal characteristics, pad characteristics, missile travel time, and initial conditions were studied to determine the sensitivity of the lateral dynamic calculations.

STRUCTURAL COMPONENTS

CABLES

(Also see No. 2213)

81-2119

Undersea Suspended Cable Structures

W.J. Nordell and D.J. Meggitt

Ocean Struc. Div., Civil Engrg. Lab., Naval Construction Battalion Ctr., Port Hueneme, CA 93043, ASCE J. Struc. Div., 107 (6), pp 1025-1040 (June 1981) 5 figs, 2 tables, 22 refs

Kr Words: Cables (ropes), Underwater structures, Suspended structures

The design, analysis and implantment of undersea suspended cable structures is explored. These structures have been located in water depths to 19,000 feet (5,800 m). The predominant external load imposed on the structures in-situ is current-induced drag; however, the design is often significantly influenced by the dynamic forces generated during implantment by the surface platform motions. Hydrostatic pressure may be the governing load in the design of some components. Analytical techniques are available for predicting the dynamic response of these structures subjected to implantment and in-situ forces. The influence of cable strumming on structural response can also be estimated. The design must consider the following: limitations to be imposed on the structure motion, the mean and maximum current profile, the corrosion and biofouling potential at the site, and the weather window for implantment. Implantment (or construction) techniques emphasize prefabrication to minimize on-site operations and time.

81-2120

Dynamic Analysis of Electric Transmission Line Systems with Broken Wires

J.F. Fleming and F. Siddiqui

Dept. of Civil Engrg., Univ. of Pittsburgh, Pittsburgh, PA, Rept. No. SETEC-CE-80-035, NSF/RA-800306, 172 pp (Sept 1980)

PB81-148108

Key Words: Transmission lines, Supports, Computer programs

A study is reported on the behavior of electric transmission line systems when one or more of the wires suddenly breaks. Special attention focused on the variation with time of the longitudinal unbalanced loads in the system to determine maximum values for design of the support structures. The investigation comprised three parts: broken wire analysis; development of a computer program for dynamic analysis; and design of transmission line systems for broken wires. The computer program performs a dynamic analysis of a general line system after any number of wires are broken. A lumped mathematical model was used and nonlinear equations of motion were solved using two different numerical analysis procedures. The nonlinearity of the system is due to the nonlinear sag-tension relationship for the suspension insulators. A preliminary parametric study shows that dynamic loads and ground line moments which are more than four times the residual static values can be expected in typical line systems.

BARS AND RODS

81-2121

Fracture Mechanics and Dynamic Response of Structures

J.C. Amazigo

Rensselaer Polytechnic Inst., Troy, NY, Rept. No. ARO 14732.2-E, 10 pp (Nov 1980)

AD-A095-272

Key Words: Dynamic buckling, Fracture properties

A method is developed for the optimization against buckling of structures that undergo snap buckling. An assessment is made on the range of validity of the dominant term in the singular field solution for stationary cracks. The mathematical problems arising in the elastic-plastic crack growth problems are highlighted.

BEAMS

(Also see Nos. 2154, 2204, 2270)

81-2122

Dynamic Behavior of Continuous Beams with Moving Loads

T. Hayashikawa and N. Watanabe

Dept. of Civil Engrg., Hokkaido Univ., Nishi 8 Kita 13 Kita-Ku, Sapporo, 060, Japan, ASCE J. Engr. Mechanics Div., 107 (1), pp 229-246 (Feb 1981) 14 figs, 2 tables, 20 refs

Key Words: Beams, Continuous beams, Moving loads, Lateral vibration, Variable cross section

An analytical method for determining eigenvalues and eigenfunctions of continuous beams with arbitrary boundary conditions is developed by using a general solution of a differential equation for the lateral vibration of the beam. This method can be applied to nonuniform cross section beams and calculated to higher eigenvalues very accurately. The dynamic response of a continuous beam traversed by a moving load with constant velocity is studied. The analysis is conducted by the method of modal analysis. Numerical examples are presented to illustrate the applicability of the analysis and to investigate the dynamic characteristics of continuous beams.

81-2123

Dynamic Response of Elastic Cylindeis in Fluid Layer

B.D. Westermo
Dept. of Civil Engrg., San Diego State Univ., San Diego, CA 92182, ASCE J. Engr. Mechanics Div., 107 (1), pp 187-205 (Feb 1981) 9 figs, 18 refs

Key Words: Beams, Cylinders, Interaction: structure-fluid, Foundation excitation

The dynamics of multiple cylindrical elastic beams in a horizontal fluid layer are examined. The hydrodynamic interaction forces on the cylinders, due to the base motion of the entire array, are formulated, and these forces are applied to an elastodynamic beam equation to investigate both the beam-fluid and the beam-fluid-beam interaction. The fluid is taken to be water and is assumed to be linearly compressible and represented by potential flow theory. The cylindrical beams are modeled by Euler-Bernoulli beam theory. The hydrodynamic force distribution, mode shapes, and the frequency response of the beams to harmonic base excitation are presented. The multiple cylinder fluid interaction has significant effects in the dynamic response of the system, particularly for frequencies higher than the first natural frequency of a free beam. The interaction response is strongly dependent on the direction of the base excitation.

81-2124

On Numerical Nonlinear Analysis of Highly Flexible Spinning Cantilevers

S. Utku, M. El-Essawi, and M. Salama
Dept. of Civil Engrg., Duke Univ., Durham, NC 27706, Computers Struc., 13 (1-3), pp 349-355 (June 1981) 1 fig, 8 refs

Key Words: Cantilever beams, Rotating structures, Computer programs

The general nonlinear discretized equations of motion of spinning elastic solids and structures are derived as a set of nonlinear ordinary differential equations for the case when the strain-displacement and velocity-displacement relations are nonlinear up to the second order. It is shown that the cost of generation of such equations is proportional to the fourth power of the number of degrees of freedom. A computer program is written to automatically generate the equations for the case of spinning cantilevers with initial imperfections. The types and the number of the coordinate functions used in the trial solution ar. parameters of the program.

81-2125

A Nonlinear Theory of General Thin-Walled Beams

D. Meredith and E.A. Witmer
Meredith Engrg., 33170 Glen Valley Dr., Farmington Hills, MI 48018, Computers Struc., 13 (1-3), pp 3-9 (June 1981) 5 figs, 12 refs

Key Words: Beams, Transient excitation, Impact response (mechanical), Computer programs

A complete and consistent theory is formulated to describe the large-deflection elastic-plastic behavior of thin-walled beams of arbitrary initial shape and subjected to arbitrary transient loadings. The nonlinear beam theory is derived from a well-documented nonlinear shell theory through an application of Hamilton's Principle. By interpreting classical beam theory displacement fields as the lower order terms in a more general series expansion of deformation modes which describe the behavior of the beam cross section, a higher order beam theory based on such an expansion can be developed. The theory can be sufficiently general so as to incorporate the effects of cross-sectional distortion and collapse in addition to the complete range of behavior normally associated with beam theory (translation, extension, bending, transverse shear deformation, torsion, and warping). The generalized equations of motion associated with this series or modal technique are shown to be of the same form as the generalized equations of shell theory from which they were derived. These nonlinear equations of motion for the beam are cast into an approximate form suitable for implementation on a digital computer.

81-2126

Finite Element Prediction of Damping in Beams with Constrained Viscoelastic Layers

C.D. Johnson, D.A. Kienholz, and L.C. Rogers

Anamet Labs., Inc., Appl. Mechanics Div., San Carlos, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 51, Pt 1, pp 71-81 (May 1981) 10 figs, 11 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Beams, Layered materials, Viscoelastic properties, Vibration control, Damping, Finite element technique

Vibration control in structures by means of viscoelastic material in constrained layers has gained wide acceptance, particularly in the aerospace industry. A key to increased use of damping technology is the ability to analyze and define the candidate viscoelastically damped structure accurately and efficiently in a project environment. This paper describes and establishes the validity of the modal strain energy approach, implemented with finite element techniques, for damped, laminated beams. The modal strain energy approach uses the modal strain energy distributions, obtained by purely elastic analysis, to predict modal damping (loss) factors. These distributions may also be used by a designer as a tool to choose the best location and material for optimum damping. The approach described in the paper may easily be extended to complex structures.

81-2127

Vibrations of a Beam under Moving Loads by a Finite Element Formulation Consistent in Time and Spatial Coordinates

J.J. Wu

U.S. Army Armament Res. and Dev. Command, Large Caliber Weapon Systems Lab., Benet Weapons Lab., Watervliet, NY 12189, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 111-130 (May 1981) 14 figs, 10 tables, 14 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Beams, Moving loads, Finite element technique, Bernoulli-Euler method

A finite element formulation, which discretizes the time dimension in the same manner as it does to the special dimension, is presented and applied to the vibration analysis of elastic beams under moving load and to the lateral motions of a gun tube affected by a moving projectile. The procedure is based on an unconstrained variational approach. Bi-cubic polynomials are used as element shape functions. "Stiffness" matrices and "force" vectors integrated both in time and spatial coordinates are described. The versatility of this formulation is demonstrated by numerical results obtained for moving loads with constant and variable velocity beams with sundry support conditions and with differential equations which can be nonself-adjoint and with variable coefficients. Numerical convergence of several simple cases have been verified with a series solution. Results of motions of a typical cannon tube are included.

81-2128

Beam Motions under Moving Loads Solved by Finite Element Method Consistent in Spatial and Time Coordinates

J.J. Wu

Large Caliber Weapon Systems Lab., Army Armament Res. and Dev. Command, Watervliet, NY, Rept. No. ARLCB-TR-80046, AD-E440 103, 26 pp (Nov 1980) (Pres. at the Conf. of Army Mathematicians, 26th Cold Regions Res. and Eng. Lab., Hanover, NH, June 10-12, 1980)
AD-A094 712

Key Words: Beams, Moving loads, Finite element technique

A solution formulation and numerical results are presented here for the time-dependent problem of beam deflections under a moving load which can be neither a force nor a mass. The basis of this approach is the variational finite element discretization consistent in spatial and time coordinates. The moving load effect results in equivalent stiffness matrix and force vector which are evaluated along the line of discontinuity in a time-length plane. Numerical results for several problems have been obtained, some of which are compared with solutions obtained by Fourier series explanations.

81-2129

Steady-State Vibrations of a Beam on a Pasternak Foundation for Moving Loads

H. Saito and T. Terasawa

Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 879-883 (Dec 1980) 7 figs, 15 refs

Key Words: Beams, Pasternak foundations, Moving loads, Periodic response

The response of an infinite beam supported by a Pasternak-type foundation and subjected to a moving load is investigated. It is assumed that the load is uniformly distributed over the finite length on a beam and moves with constant velocity. The equations of motion based on the two-dimensional elastic theory are applied to a beam. Steady-state solutions are determined by applying the exponential Fourier transform with respect to the coordinate system attached to the moving load. The results are compared with those obtained from the Timoshenko and the Bernoulli-Euler beam theories, and the differences between the displacement and stress curves obtained from the three theories are clarified.

CYLINDERS

(Also see No. 2161)

81-2130

Parametric Resonance Oscillations of Flexible Slender Cylinders in Harmonically Perturbed Axial Flow. Part 1: Theory

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J. Appl. Mechanics, Trans. ASME, 47 (4), pp 709-714 (Dec 1980) 6 figs, 15 refs

Key Words: Cylinders, Fluid-induced excitation, Parametric resonance

This paper reports on the theoretical dynamical behavior of a flexible slender cylinder in pulsating axial flow. The dynamics of the system in steady, unperturbed flow are examined. For various sets of boundary conditions the eigenfrequencies of the system at any given flow velocity are determined, and the critical flow velocities are established, beyond which buckling (divergence) would occur. The behavior of the system in pulsating flow is examined next, establishing the existence of parametric resonances. The effects of the mean flow velocity, boundary conditions, dissipative forces, and virtual (hydrodynamic) mass on the extent of the parametric instability zones are then discussed.

81-2131

Parametric Resonance Oscillations of Flexible Slender Cylinders in Harmonically Perturbed Axial Flow. Part 2: Experiments

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Dept. of Mech. Engrg., McGill Univ., 817 ouest, rue Sherbrooke, Montreal, Quebec, H3A 2K6, Canada,
J. Appl. Mechanics, Trans. ASME, 47 (4), pp 715-719 (Dec 1980) 4 figs, 4 refs

Key Words: Cylinders, Fluid-induced excitation, Parametric resonance

This paper examines experimentally the dynamical behavior of a flexible slender cylinder in axial flow, perturbed harmonically in time. Parametric resonance oscillations were found to exist over certain ranges of frequencies and amplitudes of flow-velocity perturbations. The most prominent of the resonances, in these experiments, were associated with the second-mode principal primary resonance, and were studied extensively. Agreement with theory was found to be quite good.

81-2132

Vibrations of Solid Cylinders

J.R. Hutchinson
Dept. of Civil Engrg., Univ. of California, Davis, CA 95616,
J. Appl. Mechanics, Trans. ASME, 47 (4), pp 901-907 (Dec 1980) 12 figs, 3 tables, 14 refs

Key Words: Cylinders, Natural frequencies, Series (mathematical)

A series solution of the general three-dimensional equations of linear elasticity is developed and used to find accurate natural frequencies for the vibrations of solid elastic cylinders with traction-free surfaces. The series solution is found to converge to accurate frequencies with the use of very few terms. Results are given for height-to-diameter ratios from zero to two and a frequency parameter $\omega R/C_s$ from zero to five and for modes of circumferential order from zero to four. Comparisons of these analytical results with previous experimental results shows excellent agreement.

COLUMNS

81-2133

Behavior Classification of Short Reinforced Concrete Columns Subjected to Cyclic Deformations

K.A. Woodward and J.O. Jirsa
Ferguson Structural Engrg. Lab., Texas Univ., Austin, TX,
Rept. No. PMFSEL-80-2, NSF/RA-800378, 357 pp (July 1980)
PB81-158222

Key Words: Columns (supports), Reinforced concrete, Cyclic loading

Guidelines were developed for describing and predicting the behavior of short reinforced concrete columns subjected to cyclic reversed deformations. The guidelines are presented in a flowchart encompassing a broad range of behavior. The end result is a unified approach to classifying and describing the hysteretic behavior of the columns. Eleven short columns were tested, the majority of which were subjected to cyclic deformations applied along two orthogonal axes. A constant compressive axial load was also applied to the majority of the columns. Results of the tests showed a wider range of behavioral characteristics than was expected. Based on test results, a predictive guide was developed to provide a rationale for understanding column behavior under cyclic loading conditions.

FRAMES AND ARCHES

(Also see No. 2115)

81-2134

Experiment to Study Earthquake Response of R/C Structures with Stiffness Interruptions

J.P. Moehle

Ph.D. Thesis, Univ. of Illinois, 435 pp (1980)

UM 8108608

Key Words: Frames, Reinforced concrete, Seismic response, Experimental test data

The object of the study was to develop improved understanding of the earthquake response of reinforced concrete structures having abrupt interruptions in the lateral-force-resisting elements in adjacent stories. The study comprises both experimental and analytical phases. Experimental work includes earthquake simulation tests of four small-scale, reinforced concrete structures and static tests of small-scale members and member assemblies which were representative of elements composing the test structures. Analytical work includes evaluation of several simple linear and nonlinear numerical models with emphasis on use of readily-available, approximate analysis or design methods.

81-2135

Shaking Table Testing of a Reinforced Concrete Frame with Biaxial Response

M.G. Oliva

Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/28, NSF/RA-800366, 207 pp (Oct 1980)

PB81-154304

Key Words: Frames, Reinforced concrete, Seismic excitation, Experimental test data

The program in this report involved testing of a one third scale two story reinforced concrete frame, having rectangular section columns, with inelastic biaxial motion induced through earthquake excitation on a shaking table. Close inspection of the experimental response, and comparison with previous test results on a similar frame under pure uniaxial motion, found that biaxial motion seriously reduced the column yield strength. Local and global response characteristics indicated a tremendous amount of interaction between the rectangular column's strong axis motion and weak axis response.

81-2136

Elastic-Plastic Seismic Response Analyses of Structures Supporting Steam Generators

Y. Nakao, Y. Murase, and H. Kohata

Struc. and Vib. Res. Lab., Hiroshima Tech. Inst., Technical Headquarters, Computers Struc., 13 (1-3), pp 205-211 (June 1981) 14 figs, 1 table, 7 refs

Key Words: Seismic response, Framed structures, Boilers, Modal superposition method, Mass condensation method

Three dimensional elastic-plastic seismic response analysis of structures supporting steam generators is carried out. The structural system is idealized as a finite element model composed of elastic beam elements and partially of nonlinear spring elements. In the equation of motion the nonlinear restoring force term is divided into a linear term and a nonlinear term, the latter being moved to the right hand side of the equation and regarded as an external force term. The equation is solved by using the mode superposition method accompanied by the mass condensation method. The analysis method is shown to be of practical use by applying it to a scaled model and to an actual structure.

81-2137

Load-Frequency Relationships for Shallow Elastic Arches

E.R. Johnson and R.H. Plaut

College of Engrg., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. VPI-E-80-4, 70 pp (Feb 1980)

PB81-156473

Key Words: Arches, Natural frequencies, Fundamental frequency

This report investigates load-frequency relationships for shallow elastic arches. The results are presented as characteristic curves, which are plots of the squares of the vibration frequencies versus a static loading parameter. The curve corresponding to the lowest frequency is called the fundamental characteristic curve. Properties of these curves, in particular the fundamental one, can provide insight into dynamic response and sometimes can be used to estimate vibration frequencies and buckling loads. In this report, a shallow arch with sinusoidal initial shape is treated. A sinusoidal distributed load is applied, and characteristic curves are determined for various values of the arch rise parameter. An asymmetric loading and general symmetric loading are also considered briefly. Circular arches are analyzed. Both pinned and clamped ends are considered, and the applied load is distributed uniformly over the span.

MEMBRANES, FILMS, AND WEBS

81-2138

Vibrations of a Rectangular Membrane with an Eccentric Inner Circular Boundary: A Comparison of Approximate Methods

P.A.A. Laura and R.H. Gutiérrez

Inst. of Appl. Mechanics, Puerto Belgrano Naval Base, 8111 Argentina, J. Sound Vib., 75 (1), pp 109-115 (Mar 8, 1981) 2 figs, 3 tables, 8 refs

Key Words: Membranes (structural members), Rectangular membranes, Fundamental frequency, Ritz method, Finite element technique, Fourier analysis

Three different approaches are used in order to obtain, independently, fundamental eigenvalues of the mechanical system under study: the Ritz method, the finite element algorithm and a Fourier expansion - collocation scheme. The agreement can be considered as very reasonable, especially in view of the relatively simple formulation of the Ritz approach in which two polynomial co-ordinate functions are employed. The results may also be of interest to acousticians and microwave specialists since they are applicable to soft-walled acoustical waveguides and TM modes in electromagnetic waveguides.

PANELS

81-2139

Field Insulation of Load-Bearing Sandwich Panels for Housing

R.E. Jones

Forest Products Lab., Forest Service, U.S. Dept. of Agriculture, Box 5130, Madison, WI 53705, Noise Control Engrg., 16 (2), pp 90-105 (Mar-Apr 1981) 18 figs, 2 tables, 25 refs

Key Words: Panels, Sandwich structures, Acoustic insulation

Efficient utilization of materials can often be enhanced by employing composites comprised of several materials to obtain a combined performance not available from single materials. Constructions consisting of thick, lightweight cores sandwiched between thin, dense facings are an example in which structural advantages can be obtained while minimum amounts of materials are utilized. These sandwich constructions have been employed in a variety of structural applications. As an alternative construction for housing, the basic sandwich panel has an intrinsic sound insulation limitation due to its lightweight, high stiffness and integral construction. The need to upgrade the basic sandwich panel to meet current codes and guides for most uses in multifamily dwellings is demonstrated.

81-2140

Effect of Stiffener Arrangement on the Random Response of a Flat Panel

R.B. Bhat and T.S. Sankar

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 81-87 (May 1981) 6 figs, 8 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Panels, Stiffened panels, Random response, Mean square response

The effect of stiffener arrangement on the random response of a flat panel is investigated. The panel is stiffened in two orthogonal directions and simply supported on all edges. A stationary random load whose power spectral density is a band limited white noise, acts at the geometric center of the panel. The mean square values of displacement, velocity and acceleration responses at the center of the panel as well as the space averaged values of these responses over the entire area of the panel are obtained. Equivalent viscous damping of the structure is included to account for the structural damping in the material of the panel. Response analysis is carried out by the normal mode approach using finite element techniques and generalized harmonic analysis with damping assumed proportional to the mass and stiffness. It is concluded that it is possible to reduce the response of a stiffened structure by a nonuniform arrangement of the stiffeners. The results are discussed for design applications.

81-2141

Response of Clamped Sandwich Panels with Viscoelastic Core under Random Acoustic Excitation

C.V.R. Reddy, N. Ganesan, and B.V.A. Rao
Structures Section, ISRO Satellite Centre, Bangalore 560058, India, J. Sound Vib., 75 (4), pp 481-494 (Apr 22, 1981) 7 figs, 4 tables, 23 refs

Key Words: Panels, Sandwich structures, Viscoelastic core-containing media, Random excitation, Acoustic excitation, Harmonic analysis

Both theoretical and experimental studies have been made to evaluate the acceleration response of square sandwich panels with clamped boundaries under a specific random acoustic excitation. Generalized harmonic analysis was used to compute the response spectrum. The modal frequencies and associated loss factors of the composite used in the analytical estimation of the response were obtained by applying Galerkin's procedure. The effects of modal cross coupling and of the core thickness on the response have been studied. The theoretical estimates of the response are compared with the results from the experiments for certain core thicknesses.

81-2142

Acoustic and Vibration Fields Generated by Ribs on a Fluid-Loaded Panel, I: Plane-Wave Problems for a Single Rib

D.G. Crighton and G. Maidanik
Dept. of Appl. Mathematical Studies, Univ. of Leeds, UK, J. Sound Vib., 75 (3), pp 437-452 (Apr 8, 1981) 1 fig, 2 tables, 7 refs

Key Words: Panels, Ribs (supports), Membranes (structural members), Fluid-induced excitation, Acoustic response, Vibration response

This paper presents an analytical study of the interaction between incident wave fields, and a single rib on a fluid-loaded panel. The panel is modeled as an infinite membrane (with frequency dependent tension to partially simulate the dispersion characteristics of a thin elastic plate), and the incident waves are taken as plane structural or acoustic waves at normal and oblique incidence on the rib. The principal concern of this paper is with the structural wave field transmitted across the rib (in the case of infinite mechanical impedance and finite non-local rib impedance) though the non-specular acoustic field scattered by the panel-plus-rib is also examined.

PLATES

81-2143

The Steady-State Response of a Rotating Damped Disk of Variable Thickness

T. Irie, G. Yamada, and S. Aomura
Dept. of Mech. Engrg., Hokkaido Univ., North-13, West-8, Sapporo 060, Japan, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 896-900 (Dec 1980) 6 figs, 1 table, 14 refs

Key Words: Disks (shapes), Damped systems, Variable cross section, Rotating structures, Periodic response, Matrix methods

The stress distribution and steady-state response of a rotating damped annular disk of variable thickness are determined by means of the matrix method. The equation of equilibrium and the equations for the flexural vibration of the rotating disk are written as a respective coupled set of first-order differential equations by use of the matrices of the disk. The elements of the matrices are calculated by numerical integration of the equations, and the stress components and the driving-point impedance and force transmissibility of the disk are obtained by using these elements. The method is applied to free-clamped rotating disks with linearly, exponentially, and hyperbolically varying thickness driven by a harmonic force at the free outer edge, and the effects of the angular velocity and the variable thickness are studied.

81-2144

Application of Hamilton's Law to Forced, Damped, Stationary Systems

C.D. Bailey
Dept. of Aeronautical and Astronautical Engrg., Ohio State Univ., Columbus, OH 43210, J. Sound Vib., 75 (1), pp 117-126 (Mar 8, 1981) 24 refs

Key Words: Plates, Circular plates, Hamiltonian principle, Damped structures

The algebraic equations for the forced, damped, periodic, axisymmetric motion of circular plates, solid and annular, are derived directly through the application of Hamilton's law of varying action. The simplicity, for many problems, of direct analytical solutions by means of Hamilton's law has previously been demonstrated. The method is called the Hamilton-Ritz method. In this paper, direct analytical solutions from Hamilton's law are shown to be exactly the same as direct analytical solutions from the ancient and fundamental principle of virtual work. The Hamilton-Ritz

formulation is compared to the Galerkin formulation. Results from one- and two-term solutions by direct virtual work (Hamilton-Ritz) are compared to results from the exact solution and to results from the Galerkin method.

analyzed. Incorrectness in the generalized forces of the previous analyses is pointed out by comparing with the present analysis.

81-2145
Large Deflection of a Rigid-Viscoplastic Impulsively Loaded Circular Plate

W. Idczak, CZ. Rymarz, and A. Spychala

J. Tech. Phys., 21 (4), pp 473-487 (1980) 11 figs, 22 refs

Key Words: Plates, Circular plates, Shells, Impact response (mechanical)

The method as well as the results are presented of a behavior analysis of thin, rigid-viscoplastic circularly symmetrical plates clamped on perimeter and loaded dynamically by a shock wave with a course prescribed in time. Such a plate after having attained large deflections works as a shell. The present considerations concern changes in time, deflection speeds of the respective points of the shell, strains and elongations in the principal directions as well as the effect of the physical properties of the material upon the motion process.

81-2146
Reexamination of Unsteady Fluid Dynamic Forces on a Two-Dimensional Finite Plate at Small Mach Numbers

Y. Matsuzaki and T. Ueda

Natl. Aerospace Lab., Jindaiji, Chofu, Tokyo, Japan,
J. Appl. Mechanics, Trans. ASME, 47 (4), pp 720-724 (Dec 1980) 1 fig, 3 tables, 15 refs

Key Words: Plates, Fluid-induced excitation, Fourier transformation

The Fourier transform theory is applied to the analytical determination of the disturbance velocity potential and pressure acting on a two-dimensional plate, in order to reexamine those of previous analyses by other investigators. Simplified expressions of the generalized forces are presented for incompressible and nearly incompressible flows. As the Mach number tends to zero, the virtual mass induced by an oscillating fluid becomes infinitely large for a natural mode symmetric with respect to the midchord point. It is recommended to take into account a symmetric mode which changes no fluid volume contained in a control surface, when a coupled flutter oscillation at very low Mach numbers is

81-2147
Transient Radiation Field from an Elastic Circular Plate Excited by a Sound Pulse

I. Nakayama, A. Nakamura, and R. Takeuchi

Inst. of Scientific and Industrial Res., Osaka Univ., Yamadakami, Suita, Osaka 565, Japan,
Acustica, 46 (3), pp 276-282 (Nov 10, 1980) 6 figs, 9 refs

Key Words: Plates, Circular plates, Acoustic excitation

Fairly accurate far-field transient radiation fields from an elastic clamped circular plate are derived when the plate is excited by a normal incident plane sound pulse. By assuming the simple expression for the radiation impedance of the vibrating plate, the impulse response of this pressure field is obtained. By using the convolution integral, the pressure field of the circular plate subjected to the triangular sound pulse is examined and is compared with the exact pressure field. The process of the transient sound radiation is discussed in comparison with one due to the piston-like vibration of the plate, especially in view of the first shock of the radiated waveform.

81-2148
Finite Element Analysis of the In-Plane Behaviour of Annular Disks

V. Srinivasan and V. Ramamurti

Indian Inst. of Tech., Madras-600036, India,
Computers Struc., 13 (4), pp 553-561 (Aug 1981) 6 figs, 4 tables, 9 refs

Key Words: Annular disks, Disks (shapes), Finite element technique, Fourier series

In-plane analysis of annular disks using the finite element method is presented. A semi-analytical, one-dimensional finite element model is developed using a Fourier series approach to account for the circumferential behavior. Using displacement functions which are exact solutions of the two dimensional elasticity plane stress problem, the shape functions, stiffness matrices and mass matrices corresponding to the 0th, 1st and nth harmonics are derived. To show the utility of this new element, example problems have been solved and compared with the exact solution. The present element can be readily coded into any general purpose finite element program.

81-2149

Large-Deflection and Large-Amplitude Free Vibrations of Laminated Composite-Material Plates

J.N. Reddy and W.C. Chao

Dept. of Engrg. Science and Mechanics, Virgnia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Computers Struc., 13 (1-3), pp 341-347 (June 1981) 10 figs, 41 refs

Key Words: Plates, Composite structures, Fiber composites, Large amplitudes

Finite-element analysis of the large-deflection theory (in von Karman's sense), including transverse shear, governing moderately thick, laminated anisotropic composite plates is presented. Linear and quadratic rectangular elements with five degrees of freedom (three displacements, and two shear rotations) per node are employed to analyze rectangular plates subjected to various loadings and edge conditions. Numerical results for bending deflections, stresses, and natural frequencies are presented showing the parametric effects of plate aspect ratio, side-to-thickness ratio, orientation of layers, and anisotropy.

81-2150

Dynamic Behaviour of Isotropic Plates under Combined Acoustic Excitation and Static In-Plane Compression

R.G. White and C.E. Teh

Inst. Sound Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 75 (4), pp 527-547 (Apr 22, 1981) 15 figs, 4 tables, 14 refs

Key Words: Plates, Rectangular plates, Acoustic excitation, Random excitation, Natural frequencies, Mode shapes

A study is described which was carried out to investigate the dynamic response of an aircraft-type aluminium alloy plate, with fully clamped boundaries, subjected to combined acoustic excitation and uniaxial in-plane compression. Experiments were conducted in an acoustic tunnel with sound pressure levels up to 160 dB. The non-linear characteristics of the plate have been examined under sinusoidal and broad band random excitation and a study made of the statistical and spectral properties of the response. Theoretical and experimental estimates of the plate natural frequencies and mode shapes are described.

81-2151

Flexural Wave Baffling by Use of a Viscoelastic Material

S.-H. Ko

New London Lab., Naval Underwater Systems Ctr., New London, CT 06320, J. Sound Vib., 75 (3), pp 347-357 (Apr 8, 1981) 3 figs, 1 table, 11 refs

Key Words: Plates, Baffles, Viscoelastic properties, Flexural waves

The effectiveness of baffles against flexural wave noise is discussed. A plane layer model is considered, consisting of an infinite elastic plate excited by a line force, a viscoelastic layer representing the baffle, and an outer plate which separates the baffle layer from the semi-infinite fluid medium. The effectiveness of the baffle is characterized by its insertion loss.

81-2152

Vibrations of Rectangular Plates of Bilinearly Varying Thickness and with General Boundary Conditions

R.H. Gutierrez, P.A.A. Laura, R.O. Grossi

Inst. of Appl. Mechanics, Puerto Belgrano Naval Base, 8111 Argentina, J. Sound Vib., 75 (3), pp 323-328 (Apr 8, 1981) 2 figs, 1 table, 9 refs

Key Words: Plates, Rectangular plates, Variable cross section, Fundamental frequency

Results are presented for the fundamental frequency of a rectangular plate having a thickness which varies in a bilinear fashion. Translational and rotational flexibilities are taken into account at all edges. A simple algorithm, which allows one to evaluate the fundamental frequency of vibration, is derived by making use of the Ritz method and expressing the fundamental displacement function in terms of a polynomial co-ordinate function which satisfies approximately the natural boundary conditions.

81-2153

Transverse Vibrations of Rectangular Plates with Edges Elastically Restrained Against Translation and Rotation

P.A.A. Laura and R.O. Grossi

Inst. of Appl. Mechanics, Puerto Belgrano Naval Base, 8111 Argentina, J. Sound Vib., 75 (1), pp 101-107 (Mar 8, 1981) 3 figs, 1 table, 6 refs

Key Words: Plates, Rectangular plates, Flexural vibration, Fundamental frequency, Rayleigh-Ritz method

The fundamental frequency coefficient for a rectangular plate with edges elastically restrained against both translation and rotation is calculated by using polynomial coordinate functions and the Rayleigh-Ritz method. The approach is simple and straightforward and allows the solution of a rather difficult elastodynamics problem. Complicating factors (orthotropic properties, in-plane forces, concentrated masses, etc.) can also be taken into account without formal difficulties.

81-2154

Vibration and Buckling Calculations for Rectangular Plates Subject to Complicated In-Plane Stress Distributions by Using Numerical Integration in a Rayleigh-Ritz Analysis

M.M. Kaldas and S.M. Dickinson

Faculty of Engrg. Science, Univ. of Western Ontario, London, Ontario, Canada N6A 5B9, J. Sound Vib., 75 (2), pp 151-162 (Mar 22, 1981) 5 figs, 4 tables, 19 refs

Key Words: Plates, Rectangular plates, Beams, Rayleigh-Ritz method, Flexural vibration

A Rayleigh-Ritz approach, in which appropriate beam characteristic functions are used in the deflection series, is presented for the solution of the elastic buckling and flexural vibration problems of thin rectangular plates which may be subject to any practical in-plane stress field. The stress distribution may be described in the form of mathematical expressions or by means of a set of values known only at discrete points within the plate; typically the former description may be derived from a classical two-dimensional elasticity solution and the latter from a finite difference or finite element analysis. The integrations associated with the in-plane stresses in the strain energy expression are performed numerically by using a technique based upon natural bicubic spline interpolation, the computer subroutines for which are available to the general scientific public. Several numerical examples of varying complexity are presented, illustrating the accuracy and applicability of the proposed approach.

81-2155

The Flexural Vibration of Welded Rectangular Plates

M.M. Kaldas and S.M. Dickinson

Faculty of Engrg. Science, Univ. of Western Ontario, London, Ontario, Candada N6A 5B9, J. Sound Vib., 75 (2), pp 163-178 (Mar 22, 1981) 7 figs, 8 tables, 23 refs

Key Words: Plates, Rectangular plates, Welded joints, Flexural vibration, Finite difference technique, Rayleigh-Ritz method

A theoretical and experimental study of the effect of weld runs on the flexural vibrational characteristics of the common structural element, the rectangular plate, is described. A finite difference technique is utilized for the determination of the in-plane residual stress pattern due to the weld(s) and the Rayleigh-Ritz method, with beam characteristic functions, is used for the out-of-plane vibration analysis. The theoretical approach presented is applicable to rectangular plates of any practical aspect ratio, having any combination of out-of-plane boundary conditions for which beam functions may reasonably be used and subject to one or more weld runs parallel to any edge. Theoretical and experimental results for a number of specific plates are presented, demonstrating the effects of welding on the plate vibration and the capability and accuracy of the analytical approach in predicting these effects. Included is a study of the effect of using the full residual stress pattern as derived from the finite difference analysis, the effect of neglecting certain stress components and the effect of using simplified stress patterns developed primarily for the stress and buckling analysis of long plates.

81-2156

Recording Receptance of Flat Plates by Holographic Interferometry

C.R. Hazell

Dept. of Engrg., St. Francis Xavier Univ., Antigonish, Nova Scotia, Canada, J. Sound Vib., 75 (2), pp 275-283 (Mar 22, 1981) 3 figs, 2 tables, 16 refs

Key Words: Plates, Holographic techniques, Interferometric techniques, Receptance method

In the study of mechanical vibrations of structures, the complex ratio of the displacement of the structure at a point divided by the force input to the structure at the same point or a different point is called receptance. This ratio is usually recorded in magnitude and phase by using piezoelectric transducers attached to the structure. This paper describes a study of the feasibility of recording the displacement of a square cantilevered plate not just at one point but over the entire plate surface, by using holographic interferometry.

81-2157

Transverse Vibrations of Thin, Elastic Plates with Concentrated Masses and Internal Elastic Supports

P.A.A. Laura and R.H. Gutiérrez

Inst. of Appl. Mechanics, Puerto Belgrano Naval Base, 8111 Argentina, J. Sound Vib., 75 (1), pp 135-143 (Mar 8, 1981) 1 fig, 2 tables, 7 refs

Key Words: Plates, Rectangular plates, Circular plates, Elastic foundations, Fundamental frequency, Flexural vibration

The fundamental frequency of vibration of a plate carrying concentrated masses and with internal elastic supports is determined. The case of an orthotropic, rectangular plate elastically restrained against rotation along the four edges is tackled first by using simple polynomial approximations and the Galerkin method. Then, vibrations of clamped and simply supported isotropic plates of regular polygonal shape are studied by using the conformal mapping technique coupled with the variational method. Finally the case of a circular plate elastically restrained against translation and rotation is considered.

81-2158
Vibrations of Rectangular Plates with Nonuniform Elastic Edge Supports
A.W. Leissa, P.A.A. Laura, and R.H. Gutiérrez
Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH 43210, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 891-895 (Dec 1980) 3 figs, 2 tables, 28 refs

Key Words: Plates, Rectangular plates, Numerical analysis, Exact methods, Ritz method

Two methods are introduced for the solution of free vibration problems of rectangular plates having nonuniform, elastic edge constraints, a class of problems having no previous solutions in the literature. One method uses exact solutions to the governing differential equation of motion, and the other is an extension of the Ritz method. Numerical results are presented for problems having parabolically varying rotational constraints.

SHELLS

(Also see Nos. 2145, 2254)

81-2159
Vibrations of Conical Shells
C.H. Chang
Engrg. Mechanics, Univ. of Alabama, University, AL, Shock Vib. Dig., 13 (6), pp 9-17 (June 1981) 95 refs

Key Words: Shells, Conical shells, Natural frequencies, Mode shapes, Computer programs, Reviews

A literature review of the vibrations of conical shells is presented. The various formulations and solutions of free and forced vibrations of axisymmetric and asymmetric modes of isotropic and anisotropic conical shells are summarized. Computer programs available for computation of the frequencies and mode shapes of vibrations of conical shells of any configuration are discussed.

81-2160
Dynamic Response of Fluid-Filled Shells – An Update
F.L. DiMaggio
Dept. of Civil Engrg. and Engrg. Mechanics, Columbia Univ., New York, NY, Shock Vib. Dig., 13 (6), pp 3-5 (June 1981) 24 refs

Key Words: Shells, Fluid-filled containers, Reviews

This article reviews papers concerned with the dynamic response of shells containing fluid that were published during the past three or four years. Papers concerned only with effects of gravity (sloshing) or fluid flow are not included.

81-2161
Flexural Vibrations of Finite Cylindrical Shells of Various Wall Thicknesses – II
J. Chandra and R. Kumar
Systems Engrg. Div., Defence Sci. Lab., Metcalfe House, Delhi-110054, India, Acustica, 46 (3), pp 281-288 (Nov 10, 1980) 8 figs, 9 refs

Key Words: Shells, Cylindrical shells, Variable material properties, Flexural vibration, Cylinders

In this paper, the frequency-aspect ratio curves have been obtained for the flexural vibrations of finite, isotropic, cylindrical shells of different wall thicknesses having antisymmetric motion about their central plane. A solid cylinder is considered as a particular case of the shell. Stress free boundary conditions on the lateral surfaces of the shells have been satisfied exactly and the real, imaginary and complex branches of the dispersion spectra have been superimposed to satisfy stress-free conditions at the flat ends of the shells to a good degree of accuracy. The residual stresses and the displacements at the flat ends of the shells have been given for some random cases.

81-2162

The Effects of Wall Discontinuities on the Propagation of Flexural Waves in Cylindrical Shells

C.R. Fuller
Inst. Sound Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 75 (2), pp 207-228 (Mar 22, 1981) 13 figs, 11 refs

Key Words: Shells, Cylindrical shells, Flexural waves, Wave transmission, Discontinuity-containing media

The transmission of flexural type waves through various discontinuities in the walls of cylindrical shells is investigated. Theoretical curves of transmission loss are obtained for different circumferential wavenumbers and wave types, as functions of frequency. Material stiffness and extensional phase speed, together with the relationship between radial vibration amplitude and total wave power of propagation, are important factors which are found to strongly influence wave transmission through discontinuities. Some practical results useful for predicting the performance of typical pipe isolators (in vacuo) are obtained.

81-2163

The Bend-Buckling of a Ring-Stiffened Cylindrical Shell Due to Whipping Excitations

K.A. Bannister
Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 51, Pt 3, pp 131-142 (May 1981) 3 figs, 1 table, 31 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shells, Cylindrical shells, Whipping phenomena, Submarine hulls

The problem of interest is the bend-buckling of a ring-stiffened cylindrical shell executing a low frequency beam-like "whipping" motion in one plane. This topic is related to the design of practical ring-stiffened shell structures subjected to in-service bending loads, for example, submarine pressure hulls. The larger objective is a systematic investigation into the dependence of the critical bend-buckling load of the structure on discrete stiffener parameters such as spacing, eccentricity (whether the ring is inside or outside), shape, and area. As a simple initial study, we will focus on just one ring placed on a very long uniform shell. Three different models for the problem will then be briefly reviewed: a Dirac-δ formulation which explicitly treats discrete effects; a linear "smeared" stiffener model in which the ring is smoothed over the shell, thus effectively replacing the original ring/shell by a uniform shell with orthotropic material properties; and a numerical model using the "STAGS" finite difference computer program. Finally, calculations for typical large shells will be presented in order to compare these modals.

81-2164

Dynamic Analysis of Ring-Stiffened Circular Cylindrical Shells

D.E. Beskos and J.B. Oates
Dept. of Civil and Mineral Engrg., Univ. of Minnesota, Minneapolis, MN 55455, J. Sound Vib., 75 (1), pp 1-15 (Mar 8, 1981) 5 figs, 3 tables, 27 refs

Key Words: Shells, Circular shells, Cylindrical shells, Rings, Stiffened shells, Vibration analysis

A numerical method is developed for the dynamic analysis of ring-stiffened circular cylindrical thin elastic shells. Only circular symmetric vibrations of the shell segments and radial and torsional vibrations of the rings are considered. The geometric and material properties of the shell segments and the rings may vary from segment to segment. Free vibrations or forced vibrations due to harmonic pressure loading are treated with the aid of dynamic stiffness influence coefficients for shell segments and rings. Forced vibrations due to transient pressure loading are treated with the aid of dynamic stiffness influence coefficients for shell segments and rings defined in the Laplace transform domain. The time domain response is then obtained by a numerical inversion of the transformed solution. The effect of external viscous or internal viscoelastic damping is also investigated by the proposed method. In all the cases, the dynamic problem is reduced to a static-like form and the "exact" solution of the problem is numerically obtained.

81-2165

Pre-Calculations for Vibration Tests with a Thin-Walled, Fluid-Filled Cylindrical Shell. Test Configuration A

G. Hailfinger and R. Krieg
Projekt Nukleare Sicherheit, Kernforschungszentrum Karlsruhe GmbH, Fed. Rep. Germany, Rept. No. KFK-2884-B, 34 pp (Nov 1979)
(In German)

Key Words: Shells, Cylindrical shells, Interaction: structure-fluid

In order to support investigations in dynamic fluid structure interaction carried through within the HDR-program, additional laboratory tests have been planned. One type of test concerns the eigenfrequencies and deformation modes of a thin-walled, fluid-filled circular shell. Final goal is the verification of recently developed computational methods in dynamic fluid structure interaction. In this report the pre-calculations for a test configuration are documented.

81-2166
Nonlinear Vibration of Cord-Reinforced Composite Shells

F. Tabaddor and J.R. Stafford
B.F. Goodrich Co., 500 S. Main St., Akron, OH 44318, Computers Struc., 13 (5-6), pp 737-743 (Oct-Dec 1981) 9 figs, 2 tables, 5 refs

Key Words: Shells, Toroidal shells, Reinforced shells, Composite structures, Nonlinear vibrations, Finite element technique, Computer programs

This paper discusses ADINA finite element incremental formulations for nonlinear static and dynamic analysis of materials with nonlinear constitutive equations. The formulations are applied to axisymmetric problems of cord reinforced composites using the ADINA computer program. Numerical results on natural frequencies and mode shapes of cord reinforced inflatable toroidal shells are presented for axisymmetric modes of excitation.

81-2167
Modeling Techniques for ADINA Analysis of Stiffened Shell Structures

T.A. Giacofci
Submarine Protection Div., David W. Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD 20084, Computers Struc., 13 (5-6), pp 601-605 (Oct-Dec 1981) 12 figs, 4 refs

Key Words: Shells, Stiffened shells, Stiffener effects, Transient response, Computer programs, Mathematical models

The ADINA beam element is inadequate for transient analysis of eccentrically stiffened shell structures, particularly when the lateral stability of the stiffener is of concern. As an alternative to modeling stiffened shells with a large number of continuum or transition elements, a stiffener modeling technique based on the ADINA multi-point constraint option is presented. This technique leads to significant reductions in the number of elements and solution degrees of freedom needed for accurate stiffener modeling, yet allows effects of out-of-plane web distortion, longitudinal warping and torsion to be included in the analysis. Stiffeners with various cross section geometries and boundary conditions have been modeled and predicted response correlates well with experimental data. The approach is of practical significance for large stiffened shell problems, especially for nonlinear analysis.

81-2168
Aircraft Impact on Reinforced Concrete Shells. Influence of Material Nonlinearities on Equipment Response Spectra

T. Zimmermann, B. Rebora, and C. Rodriguez
Motor-Columbus Consulting Engineers Inc., CH-5401 Baden, Switzerland, Computers Struc., 13 (1-3), pp 263-274 (June 1981) 11 figs, 1 table, 11 refs

Key Words: Shells, Reinforced shells, Reinforced concrete, Crash research (aircraft), Finite element technique, Nuclear reactors, Containment structures

The effects of material nonlinearities on response spectra resulting from the impact of a commercial aircraft on the secondary containment of a BWR reactor are investigated. A finite element model taking into account concrete cracking and crushing and steel yielding is used for the analysis. The results show that, for the design considered here, no reduction of the response spectra due to material nonlinearity in the impact zone can be expected.

RINGS
(See No. 2164)

PIPES AND TUBES

81-2169
On the Number of Tube Rows Required to Study Cross-Flow Induced Vibrations in Tube Banks

D.S. Weaver and M. El-Kashlan
Dept. of Mech. Engrg., McMaster Univ., Hamilton, Ontario, Canada L8S 4L7, J. Sound Vib., 75 (2), pp 265-273 (Mar 22, 1981) 5 figs, 1 table, 17 refs

Key Words: Tubes, Fluid-induced excitation, Whirling, Heat exchangers

Careful experiments in which a triangular array of tubes with a pitch ratio of 1·375 was used have been undertaken to determine the minimum number of tube rows required to study flow induced vibration phenomena typical of a tube bank. Individual tube responses were monitored to examine the effects of different numbers of upstream and downstream tube rows. It was found that the critical tubes for fluid-elastic instability are in the third and fourth rows. From the point of view of studying vibrations induced by turbulence, vorticity phenomena and fluid-elastic instability, it is recommended that six tube rows be used.

81-2170

The Effect of Damping and Mass Ratio on the Stability of a Tube Bank

D.S. Weaver and M. El-Kashlan

Dept. of Mech. Engrg., McMaster Univ., Hamilton, Ontario, Canada L8S 4L7, J. Sound Vib., 76 (2), pp 283-294 (May 22, 1981) 8 figs, 2 tables, 18 refs

Key Words: Tubes, Fluid-induced excitation, Heat exchangers, Damping effects, Mass coefficients

Experiments have been conducted in a wind tunnel on a parallel triangular tube array with a pitch ratio of 1·375. The aerodynamic component of damping was determined as a function of flow velocity. This damping was found to increase linearly with flow to about 50% of the stability threshold and then to decrease. Additionally, six different sets of tubes were tested to examine the effect of mass ratio on fluid-elastic stability. The results were compared with similar experiments in which damping alone was varied. It is seen that damping and mass ratio do not appear to be linearly dependent parameters which is contrary to the assumption used commonly in the stability analysis of tube banks. More importantly, however, the stability threshold is substantially less dependent on both damping and mass ratio than indicated by conventional theory.

81-2171

Calculation of Pipes with Several Anchorage Points Subjected to Seismic Tremors

M. Livolant and F. Jeanpierre

Div. d'Etude et de Developpement des Reacteurs, CEA Centre d'Etudes Nucleaires de Saclay, Gifsur-Yvette, France, Linear and Non-linear Calculation of Piping Systems. CONF-800147-2, 31 pp (1980) Conf. held Jan 21, 1980, Paris, France (In French)
CEA-CONF-5081

Key Words: Pipes (tubes), Seismic analysis

The seismic analysis of structures secured to buildings, light or flexible enough not to modify the movement of the building itself, is generally carried out by the floor spectrum method. This method is analogous to that of the oscillator spectra used for structures resting on the ground, the ground movement being replaced by that of the securing point on the building. The purpose of this report is to describe and discuss the general methods, exact or step by step, which apply in this case.

81-2172

Dynamic Analyses of Elasto-Plastic Piping Systems Undergoing Large Deformations

J. Heifetz, M. Benjamin, and L. Listvinsky

EBASCO Services Inc., 2 World Trade Ctr., 79th Floor, New York, NY 10048, Computers Struc., 13 (1-3), pp 257-262 (June 1981) 3 figs, 16 refs

Key Words: Piping systems, Elastoplastic properties, Blowdown response, Nuclear reactor components

A finite element program development is presented for elasto-plastic piping systems subjected to severe pipe rupture blowdown forces and finite deformations. The piping consists of straight and curved elements with relatively thin walls. The effects of varying internal pressure on yielding are included but remain uncoupled from the dynamic solution process.

DUCTS

81-2173

Non-Linear Propagation in Near Sonic Flows

A.H. Nayfeh, J.J. Kelly, and L.T. Watson

Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 75 (3), pp 359-370 (Apr 8, 1981) 9 figs, 11 refs

Key Words: Ducts, Variable cross section, Sound propagation

A non-linear analysis is developed for sound propagation in a variable-area duct in which the mean flow approaches choking conditions. A quasi-one-dimensional model is used and the non-linear analysis represents the acoustic disturbance as a sum of interacting harmonics. The numerical procedure is stable for cases of strong interaction and is able to integrate through the throat region without any numerical instability.

81-2174

Active Attenuation of Noise: The Chelsea Dipole

KH. Eghtesadi and H.G. Leventhall
Dept. of Electrical Engrg., Abadan Inst. of Tech., Abadan, Iran, J. Sound Vib., 75 (1), pp 127-134 (Mar 8, 1981) 7 figs, 11 refs

Key Words: Ducts, Noise reduction, Active noise control, Antiphase technique

Methods of active attenuation of noise, that is to cancel the noise from a source by the addition of further noise, include the method of destructive interference. A number of configurations of active attenuators are possible and a new system which originated in work at Chelsea College has been developed further. This system employs two spaced secondary sources in a duct energized in antiphase, with the microphone situated centrally between them. The radiation from the secondary sources cancels at the microphone, which, ideally, responds only to the traveling wave in the duct. The microphone output is phase shifted by 90° and then amplitude compensated by a transfer function before being fed to the secondary sources, in order to bring its downstream radiation into antiphase with the traveling noise wave. There is radiation both upstream and downstream from the secondary sources, but the microphone is isolated from the resulting upstream standing waves and time delays are not required, unlike the systems employing the microphone remote from the attenuator. The action of the attenuator has been investigated on pure tones and bands of noise with a range of attenuator center frequencies.

81-2175

Evaluation of the Errors in the Measurements of Silencer Characteristics

J. Roland
Centre Scientifique et Technique du Batiment, 24 rue Joseph Fourier, 38400 St. Martin d'Heres, France, J. Sound Vib., 75 (4), pp 549-558 (Apr 22, 1981) 5 figs, 8 refs

Key Words: Ducts, Silencers, Sound transmission loss, Measurement techniques, Error analysis

This paper is concerned with an evaluation of the errors committed when measuring the transmission loss and the flow noise of silencers; these errors are mainly due to both source and end reflection. It is shown that in measuring the transmission loss, the direct method is more likely to give small errors than the substitution method. Yet whenever the substitution method is used special attention must be paid to the reflection coefficient toward the source. Moreover, it appears necessary to use rather long ducts in order to avoid the effects of axial resonances.

BUILDING COMPONENTS

(Also see No. 2194)

81-2176

Transient Response Analysis of Structural Systems with Nonlinear Behavior

M.A. Bhatti and K.S. Pister
Univ. of California, Berkeley, CA 94720, Computers Struc., 13 (1-3), pp 181-188 (June 1981) 10 figs, 8 refs

Key Words: Structural members, Cyclic loading, Framed structures, Steel, Earthquake response

This paper presents a mixed algorithm for integration of equations of motion for structural systems having evolutionary type models for cyclic behavior of their constituent elements. The global equations of motion are integrated using Newmark's method while the internal resisting forces are calculated using an explicit, fourth order Runge-Kutta scheme with the option of using a time-step smaller than that used for Newmark's method. The algorithm also takes advantage of the spatially localized nonlinear nature of the problem, in the case where nonlinearity is concentrated in discrete parts of the structure. As a numerical example, earthquake-induced response of a three-story steel frame tested on an Earthquake Simulator, is presented.

81-2177

Inelastic Seismic Analysis of Large Panel Buildings

V. Schricker and G.H. Powell
Earthquake Engrg Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/38, NSF/RA-800198, 290 pp (Sept 1980)
PB81-154338

Key Words: Structural members, Panels, Joints (junctions), Seismic response, Finite element technique, Computer programs

Large panel structures behave differently from frame and monolithic wall structures because of the distinct planes of weakness in the horizontal and vertical joints between panels. These joints may slide and open during shaking, producing large localized changes in the bending and shear stiffnesses. Special modeling techniques are thus needed for analysis of the inelastic dynamic response. A mathematical model for inelastic seismic analysis of two-dimensional large panel structures is described.

81-2178

Inelastic Buckling of Steel Struts under Cyclic Load Reversals

R.G. Black, W.A.B. Wenger, and E.P. Popov
Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/40, NSF/RA-800299, 172 pp (Oct 1980)
PB81-154312

Key Words: Struts, Steel, Braces, Structural members, Cyclic loading, Seismic excitation

Cyclic axial loading experiments simulating severe seismic conditions are described for twenty-four structural steel struts of sizes and shapes typically employed as braces in small to moderately large steel buildings. The cross-sectional geometries of the specimens were also chosen to model the larger, heavier struts. Six of the twenty-four members were pinned at one end and fixed at the other, while the remaining eighteen were pinned at both ends. The range of cross-sectional shapes included wide flanges, double-angles, double-channels, structural tees, thin and thick-walled pipes, and thin and thick-walled square tubes The responses of the specimens are evaluated and special attention paid to the effects of cross-sectional shape, end conditions, and slenderness ratio using hysteretic envelopes.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see No. 2227)

81-2179

Sound Radiation from a Circular Cylinder Subjected to Elastic Collision by a Sphere

M. Endo, S. Nishi, M. Nakagawa, and M. Sakata
Faculty of Engrg., Tokyo Inst. of Tech., Ookayama, Meguro-ku, Tokyo, Japan, J. Sound Vib., 75 (2), pp 285-302 (Mar 22, 1981) 19 figs, 1 table, 14 refs

Key Words: Sound waves, Sound propagation, Impact response, Cylinders, Spheres, Machinery components, Machinery noise

Sound radiation from a steel cylinder impacted by a steel sphere from the longitudinal or the transverse direction is studied. In order to analyze the vibration of the cylinder, Hertz's theory is incorporated to obtain an approximate value of the contact force. The influence of the impact speed and the slenderness of the cylinder on the radiation of sound waves from the vibrating cylinder is analyzed. An experimental apparatus was constructed and vibrations of the cylinder as well as the acoustic pressure radiated were measured to demonstrate the analytical results.

81-2180

Sound Propagation through Liquids in Viscoelastic Circular Cylinders

R.A. Skop
Naval Res. Lab., Washington, DC 20375, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 217-223 (May 1981) 1 fig, 12 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Sound waves, Wave propagation, Viscoelastic media, Cylindrical shells

The propagation of low frequency sound waves through liquids contained in thin walled, viscoelastic circular cylinders is studied. The analysis is based on two suppositions: the sound wave propagates along the cylinder axis and has constant properties over a cross-section transverse to this axis; and, the dynamic response of the cylinder wall can be calculated adequately from membrane hoop theory. The wall material is described by a general viscoelastic constitutive relation. The results predicted from this analysis are shown to be in good agreement with experiments conducted in viscoelastic cylinders.

81-2181

Multiple Scattering of Waves in Irregularly Laminated Composites

R.L. Weaver and J.-H. Pao

Dept. of Theor. and Applied Mechanics, Cornell Univ., Ithaca, NY 14853, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 833-840 (Dec 1980) 7 figs, 2 tables, 20 refs

Key Words: Layered materials, Composite materials, Wave diffraction, Elastic waves

The transition matrix formulation of multiple scattering is applied to the problem of wave propagation in a one-dimensional layered medium. The effect of geometrical irregularity in an otherwise periodic layered structure is investigated in detail for the case of elastic waves propagating normally to elastic layers embedded in elastic, or in viscoelastic matrix media. The irregularity is found to widen and diminish the stop bands and soften the sharp band features characteristic of a fully periodic structure, and to generate scattering losses with a consequent increase in the attenuation of the coherent wave field.

81-2182

Cost Effectiveness of Construction Noise Abatement

F.M. Kessler and P.D. Schomer

Dames & Moore, Cranford, NJ, S/V, Sound Vib., 15 (5), pp 18-22 (May 1981) 3 figs, 4 tables, 6 refs

Key Words: Noise reduction, Construction industry

Analytical models of construction site noise emissions were developed. The models were compared with noise measurements of construction activity at Fort Hood, TX. The construction noise models are used together with proposed acceptability criteria to quantify the degree of noise abatement required at Fort Hood. Data were obtained and are presented for the costs of various construction equipment and site noise abatement methods required to achieve property-line or noise-sensitive land-use criteria sound levels. Preliminary noise-abatement cost benefit relationships were developed.

81-2183

The Reflection of Acoustical Transients from Fibrous Absorptive Surfaces

J. Mathew and R.J. Alfredson

Dept. of Mech. Engrg., Monash Univ., Clayton, Victoria 3168 Australia, J. Sound Vib., 75 (4), pp 459-473 (Apr 22, 1981) 10 figs, 17 refs

Key Words: Absorbers (materials), Fiberglass, Acoustic absorption, Acoustic reflection

An investigation into the reflection of acoustical transients from a surface of fiberglass has been carried out, with an electrical spark used as the transient noise source. The fiberglass was backed by chipboard. The transient field was measured for various source and receiver positions above the surface. A computer simulation of the experiments, with both spherical and plane wave modeling of the reflection process, proved to be adequate to predict the sound field for source and receiver geometries where the angle of incidence of the wave was less than about 60 degrees. In these simulations surfaces of both local reaction and extended reaction were investigated.

81-2184

On the Prediction of Impact Noise, III: Energy Accountancy in Industrial Machines

E.J. Richards

Inst. of Sound Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 76 (2), pp 187-232 (May 22, 1981) 27 figs, 10 tables, 27 refs

Key Words: Machinery noise, Impact noise, Noise reduction, Energy dissipation, Noise prediction

It has been explained in the two previous parts of this series of papers that the peak noise level of an impact machine can be predicted in terms of the initial kinetic energy in an equivalent bag of air of the same dimensions and impact time, but that the total L_{eq} at any frequency must depend upon the vibrational energy stored in the machine following impact and in its ability to radiate such energy as sound. This paper presents a method of examining the energy balance in the machine and obtains simple and helpful expressions for the radiated sound energy in terms of the internal energy level, a "modified" radiation efficiency, a structural damping factor, and a bulkness factor. An alternative form, based upon the measured rates of change of force in the operating tool, impulse and structural response factors, modified radiation efficiency, damping factor and bulkiness factor is also presented. The diagnostic advantages of thinking in terms of the changes in each of these terms as a method of studying noise control, even for apparently continuous running processes, are illustrated by a series of case studies which include punch press analysis, bottle impacts, impacts of solid workpieces falling into bins, gearwheel noise phenomena, backlash and diesel engine noise.

81-2185

A General Theory for the Scattering of Sound by Sound

H.C. Woodsum and P.J. Westervelt

Sanders Associates, Inc., Ocean Systems Division, 95 Canal Street, Nashua, NH 03061, J. Sound Vib., 76 (2), pp 179-186 (May 22,1981) 1 fig, 17 refs

Key Words: Acoustic scattering, Perturbation theory

A general theory for the scattering of sound by sound derived in terms of a perturbation series and a formal operator solution to the non-linear acoustic wave equation. This theory extends Westervelt's 1972 second-order operator solution for the scattering of two plane waves in a non-viscous medium, which has been successfully applied to the problem of absorption of sound by sound, to include viscosity and all orders of perturbation. The perturbation series can be evaluated in a straightforward manner if the primary field is expanded in terms of damped plane waves.

SHOCK EXCITATION

(Also see Nos. 2062, 2081, 2136, 2244, 2245, 2246)

81-2186

Shock-Wave Reflection from a Plane Partition Moving in Gas

E. Wlodarczyk

J. Tech. Phys., 21 (4), pp 505-515 (1980) 6 figs, 11 refs

Key Words: Shock wave reflection

The formulae for the solution of the reflection of a stationary shock wave from a moving, nondeformable plane partition are derived. They define the parameters of state for the polytropic and the real gas behind the front of the reflected wave as a function of intensity of the incident wave.

81-2187

Influence of Temporal and Energetic Laser-Pulse Characteristics upon the Parameters of Shock Waves Generated in Plexiglass

J. Chlodziński, S. Denus, A. Dubik, A. Galkowski, K. Jach, J. Marczak, J. Owsik, and A. Sarzyński

J. Tech. Phys., 21 (4), pp 423-440 (1980) 19 figs, 17 refs

Key Words: Shock wave propagation, Lasers, Experimental test data

The results of experimental studies on the shock wave propagation in plexiglass, generated by a single laser pulse are described. The characteristics of the velocity variations of shock wave front propagation, with the application of a two-step laser pulse are included.

81-2188

Finite Element Solution of Nonlinear Fluid-Structure Interaction Problems under Hydrodynamic Shock Conditions

J.E. Jackson, Jr. and T.L. Cost

Dept. of Mech. Engrg., Clemson, SC 29631, Computers Struc., 13 (1-3), pp 167-170 (June 1981) 3 figs, 9 refs

Key Words: Interaction: structure-fluid, Transient response, Finite element technique, Hydrodynamic excitation

A method of solution for the transient response of nonlinear fluid-structure systems is presented. Finite element discretization is applied to the nonlinear hydrodynamic equations in Eulerian form. The resulting system of equations is solved by Galerkin's method via a Newton-Raphson technique. Interaction between fluid and structure is accounted for by iteratively enforcing the interface conditions. The fluid finite element mesh is redefined by linear interpolation as the system deforms. The procedures are demonstrated by solution of a one-dimensional system consisting of a single-degree-of-freedom spring-mass in contact with a perfect gas through which a shock is propagated.

81-2189

Coupling in the Dynamic Response of Nonlinear Unsymmetric Structures

O.A. Pekau and P.K. Syamal

Dept. of Civil Engrg., Concordia Univ., Montreal, Canada H3G IM8, Computers Struc., 13 (1-3), pp 197-204 (June 1981) 6 figs, 11 refs

Key Words: Nonlinear structures, Coupled response, Torsional response, Lateral response, Buildings, Seismic excitation

A procedure is presented for investigating the stability of the torsional component of response in a nonlinear unsymmetric structure subjected to translational excitation. The torsional motion is found to be unstable due to the nonlinearity of the resisting elements if the parameters of the system are such that they fall within the region bounded by the upper and the lower instability curves. Furthermore, relationships for torsional damping and other system parameters determine the minimum torsional damping necessary to stabilize the torsional component of the motion. Thus, the procedure presented herein may be applied to structures that are susceptible to lateral-torsional coupling arising from nonlinearity of the resisting elements, eccentricity between the centers of resistance and mass, or a combination of both of these factors.

81-2190

Theory and Application of Finite Element Analysis to Structural Crash Simulation

A.B. Pifko and R. Winter

Res. Dept., Grumman Aerospace Corp., Bethpage, NY 11714, Computers Struc., 13 (1-3), pp 277-285 (June 1981) 7 figs, 32 refs

Key Words: Crash research (aircraft), Collision research (automotive), Crashworthiness, Finite element technique

An increasing emphasis is currently being placed on the crashworthy design of occupant-carrying vehicles. The goal of this effort is to design vehicles that can minimize the dynamic forces experienced by occupants during a crash event while at the same time maintaining them in a survivable structural envelope. To accomplish this goal it is necessary to evaluate the dynamic crush behavior of the vehicle structure in specific crash situations. It is the purpose of this paper to discuss the computational aspects of this problem. This is accomplished by outlining the computational methods used for crash simulation, discussing the requirements of a finite element solution to the problem and then summarizing results of two large structural crash simulation problems.

81-2191

Response of Elastic Medium to a Travelling Line Load Applied in a Cylindrical Bore

A. Paplinski and E. Wlodarczyk

Polish Academy of Sci., Inst. of Fundamental Technological Res., Warszawa, Poland, J. Tech. Phys., 21 (3), pp 313-335 (1980) 5 figs, 9 refs

Key Words: Moving loads, Elastic media, Explosion effects, Underground explosions, Fourier transformation

Response of an elastic medium to a traveling line load applied in a cylindrical bore is modeled. The detonation process and the action upon the surrounding rock mass of the post-explosion gases from the explosive filling up the long shothole are discussed. The problem of a load traveling at a subseismic speed by means of Fourier transformation is solved.

81-2192

An Energy Method for the Analysis of Structures Subjected to Earthquakes

W.D. McKevitt

Ph.D. Thesis, Univ. of British Columbia, Canada (1980)

Key Words: Seismic design, Energy dissipation, Viscous damping, Hysteretic damping

Work toward developing a simple method for the aseismic design of structures considering energy dissipation as the prime design parameter is reported. Viscous damping is used to represent the non-structural energy dissipating elements in the system, and hysteretic energy dissipation is considered explicitly. A detailed parametric study of the energy dissipation characteristics of single degree of freedom systems is reported. The results and insights gained from the parametric study are incorporated into a design method which accounts explicitly for energy dissipation. The inclusion of a system strength parameter in the input of the proposed method is found to be most useful in terms of the limit state philosophy employed in the most recent editions of building codes.

81-2193

Probable Response of Earthquake Excited Linear Systems

T.C. Golden

Ph.D. Thesis, Univ. of Washington, 175 pp (1980) UM 8109730

Key Words: Seismic design, Seismic response, Failure analysis, Probability theory

The probability of the response exceeding a design allowable for the first time is of primary importance to the design of structures. This first exceedance can result in structural collapse or give an indication of a structural deficiency. Random vibration analysis methods can predict this first exceedance of a design allowable. A unique probability model was developed to predict the probability of exceeding any response threshold for a particular linear structure. This model is applicable to all linear structures with low damping and with wideband design environments. The wide-band environment examined was earthquake excitation. The approach used to develop the probability model was to examine the response characteristics. This approach de-emphasized the input random properties where many theories assume input properties that are inaccurate.

81-2194

Random Vibrations of Structures under Parametric and Non-Parametric Earthquake Loads

T.-Y. Shih

Ph.D. Thesis, Univ. of Illinois, 270 pp (1980)
UM 8108658

Key Words: Buildings, Seismic response, Earthquakes, Random vibration, Parametric excitation

The primary objective of the present study is to assess the effects of gravity force and vertical component of earthquake acceleration on the seismic response of structures. These effects have not been adequately investigated previously, especially from the point of view of random vibration. The secondary objective is to demonstrate the versatility of the mathematical theory of the Markov random process in structural dynamics applications. This study includes the following topics at increasing complexity: single degree of freedom system with linear elastic behavior, multi-degree of freedom system with linear elastic behavior, single degree of freedom system with nonlinear elastic behavior, single degree of freedom system with type I hysteretic behavior, single degree of freedom with type II hysteretic behavior, and soil-structure system.

81-2195

Distribution of Peaks in Linear Earthquake Response

A. Amini and M.D. Trifunac

Dept. of Civil Engrg., Univ. of Southern California, University Park, Los Angeles, CA, 90007, ASCE J. Engrg. Mechanics Div., 107 (1), pp 207-227 (Feb 1981) 9 figs, 3 tables, 6 refs

Key Words: Response spectra, Seismic design, Earthquake resistant structures

In the response spectrum approach to earthquake-resistant design, it is assumed that: the structure remains linear or can be modeled by an equivalent linear system; and vibrations can be described by the largest relative (or absolute) response amplitude. From the viewpoint of understanding the progressing damage, however, it is useful to determine other response characteristics which, for example, relate duration of strong shaking with all, not just the largest, relative response amplitude. A generalization of the theory of Cartwright and Longuet-Higgins is presented to describe the expected and the most probable amplitudes of local response peaks in terms of: root-mean-square amplitude of the response; a measure of the frequency "width" of the response spectrum; and total number of peaks of response.

81-2196

A Finite Element Model for Failure Initiation in Shock Loaded Structural Materials

D.W. Nicholson

Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 219-225 (May 1981) 3 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock response, Materials, Failure analysis, Finite element technique

The present article reports the basic finite element equations governing the response of a material described by a recently published constitutive model for dynamically loaded ductile structural materials. The main feature of the model is the decomposition of the material response into rate sensitive flow and damage processes. The finite element treatment is based on several assumptions regarding the intraelement and interelement distributions of the flow and damage strains. The derived equations comprise a system of ordinary differential equations in time, requiring the specification of nine material parameters.

81-2197

An Improved Recursive Formula for Calculating Shock Response Spectra

D.O. Smallwood

Sandia Natl. Labs., Albuquerque, NM 87185, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 211-217 (May 1981) 8 figs, 3 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock response spectra, Natural frequencies, High frequencies, Recursive methods

Currently used recursive formulas for calculating the shock response spectra are based on an impulse invariant digital simulation of a single degree of freedom system. This simulation can result in significant errors when the natural frequencies are greater than 1/6 the sample rate. It is shown that a ramp invariant simulation results in a recursive filter with one additional filter weight that can be used with good results over a broad frequency range including natural frequencies which exceed the sample rate.

81-2198

Study of Penetration Forces for Supersonic Warhead Designs

R. Hassett, J.C.S. Yang, J. Richardson, and H. Walpert

Naval Surface Weapons Ctr., Silver Spring, MD 20910, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 227-236 (Mqy 1981) 4 figs, 7 tables, 4 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Warheads, Penetration, Transient excitation, Ship hulls

The purpose of this study was to generate penetration forces to evaluate several preliminary warheads designed to survive severe transient loading conditions at velocities up to 762 mps into water, ship targets, and a wide variety of land targets. A preliminary investigation into each of these mediums was conducted to determine which target medium presented the most difficult applied loading conditions to the warhead structure. Results were obtained using various methods both analytical and semi-empirical for the expected range of peak deceleration loads experienced by the warhead as it penetrates water, earth and hull targets.

VIBRATION EXCITATION

(Also see No. 2189)

81-2199

The Response Spectrum Method of Solution for Displacement Excitation

F.C. Nelson

College of Engrg., Tufts Univ., Medford, MA 02155, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 205-209 (May 1981) 3 figs, 2 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Mass-spring systems, Foundation excitation, Response spectra, Hysteretic damping

The response spectrum method is formulated in terms of base displacement rather than base acceleration. This allows simpler application of the response spectrum method to spring-mass systems with multiple input motions. The method is extended to systems for which hysteretic damping is incorporated by the use of complex stiffnesses.

81-2200

A Thermomechanical Example of Auto-Oscillation

C. Panek

Ebasco Services, Inc., 2 Rector St., New York, NY 10006, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 875-878 (Dec 1980) 4 figs, 5 refs

Key Words: Rods, Thermoelasticity, Self-excited vibrations

A system which progresses repeatedly through a cyclic sequence of physical configurations (continuous or discrete), in the absence of any periodic excitation, is said to be in the state of auto-oscillation. In this paper the author examines a thin thermoelastic rod projecting from the warmer of two parallel rigid walls, their separation being slightly wider than the length of the rod.

81-2201

Jet Excitation by an Oscillating Vane

J.M. Simmons, J.C.S. Lai, and M.F. Platzer

Univ. of Queensland, Brisbane, Australia, AIAA J., 19 (6), pp 673-676 (June 1981) 4 figs, 15 refs

Key Words: Vanes, Vibrating structures

Forced vibration of a small vane located in the jet potential core is used to excite a two-dimensional turbulent jet. The experimental apparatus and the measuring techniques used to determine the mean flow and entrainment characteristics are described. At the streamwise measurement stations and test conditions, jet spreading and entrainment are found to increase significantly with increasing frequency and amplitude of vane oscillation over the steady jet values.

81-2202

Proper Vibrations of Rectangular and Triangular Cross-Sections

H.P.W. Gottlieb

School of Science, Griffith Univ., Nathan, Brisbane, Queensland 4111, Australia, J. Sound Vib., 75 (4), pp 475-480 (Apr 22, 1981) 2 figs, 12 refs

Key Words: Elastodynamic response, Rectangular bodies, Natural frequencies, Dams, Water waves

All distinct exact separable solutions to the plane-strain elastodynamic equations for proper vibrations of rectangular and triangular cross-sections are found for all cases of edge boundary conditions admitting such oscillations.

81-2203

Excitation of Rotating Circumferentially Periodic Structures

J. Wildheim
STAL-LAVAL TURBIN AB, S-612 20 Finspong, Sweden, J. Sound Vib., 75 (3), pp 397-416 (Apr 8, 1981) 7 figs, 10 refs

Key Words: Periodic structures, Rotating structures, Resonant response

This paper is mainly devoted to two things. The first is clarification of the conditions under which a force distribution fixed in space is able to excite resonance vibrations in a rotating circumferentially periodic structure. The second is the frequency dependence of the magnification factor in the vicinity of a resonance. Damping effects are excluded from the analysis.

81-2204

Vibration of an Excitation System Supported Flexibly on a Viscoelastic Sandwich Beam at Its Mid-Point

R.C. Das Vikal, K.N. Gupta, and B.C. Nakra
Dept. of Mech. Engrg., Muzaffarpur Inst. of Tech., Muzaffarpur 842003, India, J. Sound Vib., 75 (1), pp 87-99 (Mar 8, 1981) 9 figs, 17 refs

Key Words: Beams, Viscoelastic core-containing media, Vibrating structures, Stiffness coefficients

A vibration analysis of an excitation system supported flexibly on a three layer sandwich beam is presented in this paper. The flexibly supported excitation system, which is essentially the primary system, consists of a mass, a spring and a dash-pot. The beam is analyzed separately as a continuous system in a classical way and then its dynamic stiffness at the junction point is combined with that of the primary system to obtain the resultant dynamic stiffness, which in turn is used to develop the expressions for the response of the primary system and the transmissibility provided by the whole system. Both response and transmissibility are evaluated for different geometrical and physical parameters of the sandwich beam. The solution to this problem is also obtained by approximating the sandwich beam by a lumped mass supported on a spring and dash-pot. The results in the two cases are compared. Results obtained from an experimental test-rig substantiate the theoretical results.

81-2205

Non-Stationary Responses of a Non-Symmetric Non-Linear System Subjected to a Wide Class of Random Excitation

K. Kumura and M. Sakata
Dept. of Physical Engrg., Tokyo Inst. of Tech., Meguro-ku, Tokyo 152, Japan, J. Sound Vib., 76 (2), pp 261-272 (May 22, 1981) 10 figs, 12 refs

Key Words: Random excitation, Single degree of freedom systems, Nonlinear systems, Equivalent linearization method

The non-stationary variance and mean responses of a single-degree-of-freedom mechanical system with non-symmetric non-linearities subjected to a wide class of random excitation are investigated. For non-white excitation a modified equivalent linearization technique is proposed, in which the equivalent linear system is subjected to the equivalent forcing function with shifted mean. The results obtained by the present method are compared with the corresponding digital simulation results. The general form is provided for a multi-degree-of-freedom non-linear system with non-symmetric non-linearity.

81-2206

A Simplified Quasi-Gaussian Random Process Model Based on Non-Linearity

J.D. Robson
Dept. of Mech. Engrg., Univ. of Glasgow, Glasgow G12 8QQ, UK, J. Sound Vib., 76 (2), pp 169-177 (May 22, 1981) 1 fig

Key Words: Random excitation, Mathematical models, Correlation techniques, Spectral energy distribution, Nonlinear theories

The non-Gaussian response of a simple polynomial nonlinear element to Gaussian excitation is investigated, and correlation functions and spectral densities up to the fourth order are established in terms of the second order correlation function and spectral density of the excitation. Suitable choice of excitation and non-linearity parameters then permits the response to be used, either in analysis as a well-described near-Gaussian random process, or as a good approximate model of any given near-Gaussian random process.

81-2207

Vibrating Systems with Structural Damping (Schwingungen mechanischer Systeme mit Strukturdämpfung)

D. Ottl

VDI Forsch.-Heft, No. 603, 35 pp (1981) 38 figs (In German)

Key Words: Vibrating structures, Internal damping, Modal analysis

Vibrating systems in mechanical and civil engineering commonly exhibit very small internal damping. This paper treats damping due to linear visco-elastic materials and to static hysteresis in structural joints for uniaxial loads. In the first case hold linear functional equations, or linear differential equations if inner variables are introduced. Solutions are calculated by means of modal analysis. Assuming very small damping in the second case, it is possible to analyze the non-linear vibrations approximately by the averaging method of Krylov-Bogoljubov-Mitropolski. The technique is shown and applied to a simple example.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 2058, 2095, 2105, 2126)

81-2208

Some Results on the Nature of Eigenvalues of Discrete Damped Linear Systems

D.J. Inman and A.N. Andry, Jr.

Dept. of Mech. Engrg., State Univ. of New York at Buffalo, Amherst, NY 14260, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 927-930 (Dec 1980) 9 refs

Key Words: Linear systems, Damped systems, Critical damping, Underdamping, Overdamping

An analysis of the conditions under which the modes of a damped linear lumped parameter system are either all critically damped, overdamped or underdamped is presented. These conditions are derived from the definiteness of certain combinations of the coefficient matrices. Some results concerning the completeness of the eigenvectors are stated. The conditions are compared to previous results and their usefulness is illustrated by numerical examples.

81-2209

The Experimental Performance of an "On-Off" Active Damper

E.J. Krasnicki

Lord Kinematics, Erie, PA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 125-131 (May 1981) 9 figs, 3 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Active damping, Vibration isolators, Viscous damping

The experimental performance advantages of the "On-Off" active damper used in a single degree of freedom vibration isolation system have been successfully demonstrated. Utilization of the "On-Off" control scheme simplifies the hardware implementation and reduces the cost of the active damper to a point where general industrial use is feasible. In spite of its simple control scheme, the "On-Off" active damper out-performs conventional passive isolation systems with damping ratios sufficient to limit mass motion amplification at resonance. This paper illustrates the experimental performance of the "On-Off" active damper compared to analytical simulations, passive isolation systems, and experimental "Skyhook" active damper performance.

81-2210

Pneumatic Vibration Control Using Active Force Generators

S. Sankar and R.R. Guntur

Dept. of Mech. Engrg., Concordia Univ., Montreal, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 111-123 (May 1981) 8 figs, 8 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Active vibration control, Pneumatic isolators

In this paper, various design aspects of an active vibration control system are considered. Three of the design alternatives currently available are reviewed. It is shown that these three vibration control systems use either explicitly or implicitly a force generator concept. In the proposed system a general expression for the control force is chosen so that this system is representative of not only all the above three systems but also a passive system. Transmissibility characteristics of this system are studied. The results obtained indicate that by proper choice of various feedback gains it is possible to design an active vibration control system that will give the desired transmissibility characteristics.

81-2211

Active Stabilization of a Ship Borne Crane

S. Sankar and J. Svoboda

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 237-247 (May 1981) 11 figs, 2 tables (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Active control, Active damping, Cranes (hoists), Shipboard equipment response, Water waves

This paper presents the dynamic performance of an active-stabilizer for controlling a ship-borne crane under heavy weather. The governing equations are derived and solved using digital simulation. The mathematical model served as a basis for the dynamic design study of the crane system. The active-stabilizer for the crane uses a heavy compensating boom to decouple the submersible from the motion of the support ship.

81-2212

On Modeling Viscoelastic Behavior

L. Rogers

Flight Dynamics Lab., AFWAL/FIBA, Wright-Patterson AFB, OH 45433, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 55-69 (May 1981) 8 figs, 17 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Damping, Viscoelastic properties, Mathematical models

The modeling of viscoelastic behavior under sinusoidal, relaxation, creep, constant strain rate, or any other condition is unified. The areas of polymer dynamics, solid mechanics, system dynamics, structural analysis and feedback control systems are drawn upon to construct a unified mathematical treatment which is consistent with observed behavior. A procedure is established to synthesize a stress-strain constitutive differential equation appropriate for more rigorous system dynamics studies. The fractional derivative representation is established as attractive and feasible.

81-2213

The Optimization of Mechanical Dampers to Control Self-Excited Galloping Oscillations

M.D. Rowbottom

Central Electricity Generating Board, Scientific Services Dept., Harrogate HG3 1PR, UK, J. Sound Vib., 75 (4), pp 559-576 (Apr 22, 1981) 12 figs, 4 tables, 14 refs

Key Words: Dampers, Transmission lines, Self-excited vibrations, Galloping

The use of mechanical dampers for the control of the self-excited galloping of transmission lines is considered. Two particular dampers, an in-span damper and a resilient mounting, are studied, two mass representations being used. For both dampers it is possible to produce an optimum damper either by maximizing the negative damping excitation that the damped system can withstand, or by choosing the smaller logarithmic decrement of oscillation of the system to be as large as possible in the absence of excitation.

81-2214

An Algorithm for the Optimal Design of Passive Vibration Controllers for Flexible Systems

C.W. de Silva

Dept. of Mech. Engrg., Carnegie-Mellon Univ., Pittsburgh, PA 15213, J. Sound Vib., 75 (4), pp 495-502 (Apr 22, 1981) 1 fig, 1 table, 12 refs

Key Words: Dampers, Vibration dampers, Beams, Flexural vibration, Continuous parameter method, Optimization

A gradient algorithm is developed for the optimal design of discrete passive dampers in the vibration control of a class of flexible (distributed parameter) systems. A complete mathematical development is presented for slender beams in flexural vibration. The algorithm systematically seeks to make the modal damping and natural frequencies of the system reach a set of preassigned values.

81-2215

Estimation of Damping from Response Spectra

A.F. Seybert

Dept. of Mech. Engrg., Univ. of Kentucky, Lexington, KY 40506, J. Sound Vib., 75 (2), pp 199-206 (Mar 22, 1981) 4 figs, 10 refs

Key Words: Damping coefficients, Signal processing techniques, Response spectra, Error analysis

In this paper procedures for estimating damping ratio from response spectra are examined. The study is restricted to an evaluation of bias and random errors introduced by signal processing requirements. A second order system is used in the study, and a Gaussian white noise input is assumed. It is shown that, due to bias errors in estimating the response spectra, calculations of damping ratio by the peak response and half-power bandwidth methods give overestimates. Expressions for random error associated with damping ratio estimates are also developed. Random error can be minimized by maintaining a high coherence between the system input and response.

81-2216

A New Kind of Impact Damper - from Simulation to Real Design

A. Oledzki

Technical Univ. of Warsaw, Warsaw, Poland, Mech. Mech. Theory, 16 (3), pp 247-253 (1981) 11 figs, 7 refs

Key Words: Dampers, Vibration damping, Design techniques

A new kind of impact Damper was invented, while searching for application for a newly developed simulation model of a kinematic pair with backlash. Optimum parameters of the damper were obtained first from the simulation, and then the final version of the damper was built. Comparison of the damper with other known impact dampers shows its superiority in regard to damping efficiency and the nose level. Its box form design allows any number of dampers to be packed together and the whole set adapted to given vibration conditions.

81-2217

Tuned Torsional Vibration Damper under the Condition "One Cylinder Misfiring" (Das Verhalten federgerkoppelter Drehschwingungsdämpfer bei Zylinderausfall)

F. Martinek

MTZ Motortech. Z., 42 (5), pp 173-176 (May 1981) 5 figs, 2 tables, 5 refs

(In German)

Key Words: Tuned dampers, Vibration damping, Reciprocating engines

If flexible couplings are used with reciprocating engines, the torsional vibrations are usually calculated for normal operating and for misfiring of one cylinder. If a tuned vibration damper is mounted to the crankshaft, the load on the damper differs very much, depending on which cylinder is misfiring. The effect of a misfiring cylinder can result in reduced or increased damper load.

81-2218

Correction of Mathematical Models for Damped Elastic Systems by Means of Forced Vibrations (Korrektur von Rechenmodellen für gedämpfte elastische Systeme mittels gemessener erzwungener Schwingungen)

H.-P. Felgenhauer

Fortschritt-Berichte der VDI-Z., Series 11, No. 37 152 pp (1981) 24 figs, 11 tables. Summarized in VDI-Z., 123 (6), p 188 (Mar 1981) Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Dusseldorf 1, Germany, Price: 82 DM

(In German)

Key Words: Mathematical models, Damped systems, Damping characteristics

A method is described for the correction of discrete mathematical models of linear, damped elastomechanic systems using discrete nonparametric experimental models. The criterion of effectiveness is the weighted, frequency-dependent complex deflection difference between the calculated and experimentally measured results of system response. The applicability of the method is demonstrated in an example. In addition to the corrected stiffness matrix a corrected nonproportional damping matrix is obtained, from which the dissipative behavior can be derived. The correction method can be used for the identification of complete nonproportional damping matrices.

81-2219

Finite Element Analysis of Viscoelastically Damped Sandwich Structures

M.L. Soni

Univ. of Dayton Research Inst., Dayton, OH, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 97-109 (May 1981) 12 figs, 3 tables, 19 refs (51st Symp. Shock Vib., San Diego, CA, Oct 31-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Sandwich structures, Layered damping, Viscoelastic damping, Finite element technique, Frequency domain method, Mathematical models

This paper addresses the problem of finite element modeling of the sandwich type structures typical of constrained layer damping designs. Existing modeling techniques are examined and a new finite element program with improved modeling capabilities is described. The new program is applied to the frequency domain vibration analysis of viscoelastically damped sandwich structures. Damped resonance frequencies and modal loss-factors are obtained from the direct solution of complex structural equations of motion. Modal loss-factors are also calculated from the energy weighted loss-factors of components. Damped deflection shapes rather than classical normal modes are used for this purpose. The application of the developed program is demonstrated in two typical damping analyses.

FATIGUE

(Also see No. 2077)

81-2220

Fatigue Life Prediction for Simultaneous Stress and Strength Variances under Random Vibration

R.G. Lambert
Aircraft Equipment Div., General Electric Co., Utica, NY 13503, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 169-176 (May 1981) 13 figs, 3 tables, 9 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Fatigue life, Random excitation

Simple closed form expressions have been found to accurately predict the fatigue life of structures subjected to random stresses where the applied stress and the material's strength are simultaneous random variables. These equations are in familiar engineering terms. Comparisons between analytical predictions and empirical results have been shown to be good whenever such comparisons were made.

81-2221

Cyclic Plasticity Models and Application in Fatigue Analysis

I. Kalev
Natl. Res. Council - NASA Dryden Res. Associate, NASA Dryden Flight Res. Ctr., Edwards, CA 93523, Computers Struc., 13 (5-6), pp 709-715 (Oct-Dec 1981) 8 figs, 23 refs

Key Words: Fatigue life, Crack propagation

An analytical procedure for prediction of the cyclic plasticity effects on both the structural fatigue life to crack initiation and the rate of crack growth is presented. The crack initiation criterion is based on the Coffin-Manson formulae extended for multiaxial stress state and for inclusion of the mean stress effect. This criterion is also applied for the accumulated damage ahead of the existing crack tip which is assumed to be related to the crack growth rate. Three cyclic plasticity models, based on the concept of combination of several yield surfaces, are employed for computing the crack growth rate of a cracked plane stress panel under several cyclic loading conditions.

81-2222

Fatigue Crack Closure Following a Step-Increase Load

K.K. Lo
Div. of Engrg., Brown Univ., Providence, RI 02912, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 811-815 (Dec 1980) 11 figs, 14 refs

Key Words: Fatigue life, Crack propagation, Cyclic loading

A Dugdale-Barenblatt model is used to examine the effects of crack closure following a step increase in the applied cyclic loading. Complex function formulation is employed to calculate opening and contact loads. It is shown that the effect of previous history of loading on crack growth is significant only when the extent of crack growth is within about one plastic zone size.

ELASTICITY AND PLASTICITY

(Also see Nos. 2180, 2221, 2222)

81-2223

Transient Response of a Finite Crack in a Strip with Stress-Free Edges

S. Itou
Dept. of Mech. Engrg., Hachinohe Inst. of Tech., Hachinohe 031, Japan, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 801-805 (Dec 1980) 3 figs, 26 refs

Key Words: Crack propagation, Stress analysis, Photoelastic analysis

The problem of determining the dynamic stress distribution in an infinitely long isotropic homogeneous elastic strip containing a Griffith crack which is perpendicular to the edges of the strip is considered. The crack, opened by internal pressure, has Heaviside function time-dependence. Fourier and Laplace transforms are used to solve the problem with a set of dual integral equations in the Laplace transform domain. These equations are solved using the Schmidt method. The Laplace inversion of the stress-intensity factor is carried out numerically.

81-2224

The Dynamic Three-Parameter Method for Determination of Stress-Intensity Factors from Dynamic Isochromatic Crack-Tip Stress Patterns

H.P. Rossmanith
Institut f. Mechanik, Technical Univ. Vienna, Karlsplatz 13, A-1040, Vienna, Austria, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 795-800 (Dec 1980) 7 figs, 14 refs

Key Words: Crack propagation, Stress analysis, Photoelastic analysis

Correction methods for the determination of dynamic stress-intensity factors from isochromatic crack-tip stress patterns are developed within the framework of a Westergaard-type stress-function analysis where higher-order terms of the series expansions of the stress functions are retained. The results show that both corrections assist the interpretation of current photoelastic c-K-data even though the crack speeds do not exceed one third of the shear wave speed.

81-2225

Dynamic Response of the Progressively Damaging Structures

M.G. Srinivasan, G.U. Fonseka, and D. Krajcinovic
Univ. of Illinois at Chicago Circle, Chicago, IL, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 177-187 (May 1981) 11 figs, 27 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Crack propagation, Wave propagation, Method of characteristics, Damage prediction

The continuous damage theory, originally suggested by Kachanov, is extended to a dynamical problem. The theory is characterized by a kinematic state variable defining the evolution of voids and microcracks in a smoothed or statistical sense. Concentrating on brittle cracking, a simple fracture surface is proposed. The derived equations are subsequently used to solve a one-dimensional wave propagation problem using the method of characteristics. Numerical results for several pressure pulses are presented, thus illustrating a method for obtaining estimates of the damage level in a solid as a function of time and space.

81-2226

Approximate Laplace Transform Inversion in Dynamic Viscoelasticity

S.R. Swanson
Dept. of Mech. and Industrial Engrg., Univ. of Utah, Salt Lake City, UT 84112, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 769-774 (Dec 1980) 9 figs, 2 tables, 11 refs

Key Words: Laplace transformation, Viscoelasticity theory

Laplace transform techniques greatly simplify many problems in linear viscoelasticity. However, if realistic material property representations are used, inversion of the resulting transforms can be difficult. Although approximate transform inversion methods have been widely used in quasi-static viscoelastic problems, the application of these techniques to wave propagation problems has been less successful. Inaccuracy of the transform inversion has been noted previously in the literature. The present work shows that one of the numerical Laplace transform inversion techniques of Bellman can successfully be applied to dynamic viscoelasticity. Comparisons with literature solutions and exact functions indicate accuracies to within ± one percent can be obtained.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see No. 2281)

81-2227

Finite Difference Approximation Errors in Acoustic Intensity Measurements

J.K. Thompson and D.R. Tree
Dept. of Mech. Engrg., Louisiana State Univ., Baton Rouge, LA 70803, J. Sound Vib., 75 (2), pp 229-238 (Mar 22, 1981) 8 figs, 20 refs

Key Words: Acoustic measurement, Measurement techniques, Finite difference technique, Error analysis

The errors due to developmental finite difference approximations in the two-microphone acoustic intensity measurement technique are considered in this paper. Equations are developed which describe the errors in intensity measurements for point monopoles, dipoles, and lateral quadrupoles. High accuracy is shown possible with careful selection of measurement parameters for each of these sources. For the quadrupole source low frequency errors not present with other sources are demonstrated. A lower limiting frequency for intensity measurements is determined to prevent these low frequency errors.

81-2228

Statistical Errors in Acoustic Intensity Measurements

A.F. Seybert

Dept. of Mech. Engrg., Univ. of Kentucky, Lexington, KY 40506, J. Sound Vib., 75 (4), pp 519-526 (Apr 22, 1981) 4 figs, 10 refs

Key Words: Acoustic measurement, Measurement techniques, Error analysis, Stochastic processes

A bivariate stochastic process is used to evaluate sources of error in acoustic intensity measurements. Three acoustic intensity estimators are examined for both bias and random errors. All three acoustic intensity estimators are shown to be biased by the presence of a second uncorrelated acoustic source. It is further shown that the presence of phase errors introduces additional bias which may limit the accuracy at low frequency. An expression is derived for the normalized standard error of the acoustic intensity estimates. The normalized standard error is a strong function of the coherence function and the phase angle spectrum, with maximum error occurring at low frequency and low coherence. Further interpretation of the normalized standard error is given by using two monopole acoustic sources as components in the bivariate process.

81-2229

Measurement of Head Accelerations of Boxers-Feasibility Study

D.F. Hausknecht, M. Axelrod, and R. Hoard

Science Applications, Inc., Los Angeles, CA, Rept. No. SAI-068-81-513, DOT-HS-805-664, 85 pp (May 1980)

PB81-152191

Key Words: Measurement techniques, Acceleration measurement, Impact response, Head (anatomy)

The present study is a feasibility study of instrumentation boxers during a scheduled bout to obtain the needed data. A miniaturized accelerometer-transmitter would fit unobtrusively in the boxers' mouthpiece and permit blow-by-blow telemetering of head motion data to ringside for later analyses and correlation with observed responses. The feasibility of performing these measurements was examined by conducting a survey of boxing activities (professional and amateur), performing an assessment of the safety and legal requirements, and improving packaging design to enhance boxer comfort and acceptance of a mouthpiece containing the instrumentation.

81-2230

Modal Decomposition of Covariance Sequences for Parametric Spectrum Analysis

L.L. Scharf, A.A.L. Beex, and T. von Reyn

Dept. of Electrical Engrg., Colorado State Univ., Fort Collins, CO, Rept. No. TR-37, 10 pp (Mar 1981)

AD-A095 099

Key Words: Spectrum analysis, Modal analysis, Amplitude analysis, Frequency coefficients, Damping coefficients

In this paper is made the point that a wide variety of spectrum types admit to modal analysis wherein the modes are characterized by amplitudes, frequencies, and damping factors. The associated modal decomposition is appropriate for both continuous and discrete components of the spectrum. The results for sinusoids and sinusoids in white noise are interpreted in terms of in phase and quadrature effects attributable to the finite record length.

81-2231

"Quick Look" Assessment and Comparison of Vibration Specifications

J.H. Schmidt

The Marquardt Co., Van Nuys, CA 91409, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 73-79 (May 1981) 6 figs, 3 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Vibration analysis, Spectrum analysis, Periodic response, Shock response, Random response

A technique is developed by correlating sine, shock or random to the equations obtained via a response spectrum analysis solution for random vibration. By means of this correlation, which is developed for simple then complex structures, it is shown that only one analysis technique need be used to solve all or any one of the designing dynamic environments for a given structure. The proposed technique is simpler and more cost effective than standard solution techniques. Applicable assumptions and limitations are discussed.

81-2232

State-of-the-Art Assessment of Mobility Measurements - A Summary of European Results

D.J. Ewins

Imperial College, London, UK, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 15-35 (May 1981) 15 figs, 3 tables, 1 ref (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Reviews, Mobility method, Vibration measurement, Measurement techniques

Two parallel surveys have been conducted to assess the various techniques currently in use in the UK and in France for measuring structural mobility properties. A set of test structures were circulated amongst some 18 laboratories in the UK and 16 in France, all actively using measured mobility data, and their submitted results were subjected to detailed scrutiny and comparison. The different excitation methods available were all included and some attention was given to the major applications for mobility data of modal analysis and subsystems coupling. Composite graphs have been made of the submitted mobility measurements and consistency checks applied to the results of modal analysis. The survey highlighted difficulties in the transmission of mobility data and also showed the existence of a considerable degree of scatter in the different participants' definitive measurements of specific mobility parameters.

81-2233

Recent Developments in the Measurement of Acoustic Intensity Using the Cross-Spectral Method

J.Y. Chung and D.A. Blaser

Engrg. Mechanics Dept., General Motors Res. Lab., SAE Paper No. 810396

Key Words: Acoustic measurement, Measurement techniques, Noise source identification, Spectrum analysis, Cross spectral method

In recent years, the use of the cross-spectral method of measuring acoustic intensity has been shown effective in noise-source-ranking and noise-source-identification. Using a computerized data acquisition and analysis procedure, the method is efficient and accurate. Its applicability to a near-field and/or reverberant-field measurement enables the method to be used in situ.

DYNAMIC TESTS

(Also see Nos. 2079, 2092, 2289)

81-2234

An Experimental Study of Transmission, Reflection and Scattering of Sound in a Free Jet Flight Simulation Facility and Comparison with Theory

K.K. Ahuja, H.K. Tanna, and B.J. Tester

Lockheed-Georgia Co., Marietta, GA 30063, J. Sound Vib., 75 (1), pp 51-85 (Mar 8, 1981) 28 figs, 1 table, 10 refs

Key Words: Aircraft noise, Test facilities, Calibrating

When a free jet (or open jet) is used as a wind tunnel to simulate the effects of flight on model noise sources, it is necessary to calibrate out the effects of the free jet shear layer on the transmitted sound, since the shear layer is absent in the real flight case. In this paper, a theoretical calibration procedure for this purpose is first summarized; following this, the results of an experimental program, designed to test the validity of the various components of the calibration procedure, are described. Finally, the effects of sound absorption and scattering by the shear layer turbulence are also examined experimentally.

81-2235

Random Impact Vibration Testor

W.D. Everett

Pacific Missile Test Center, Point Mugu, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 23-30 (May 1981) 7 figs, 4 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Vibration tests, Test equipment and instrumentation, Flight vehicles, Impact response (mechanical)

The Random Impact Vibration Testor (RIVT) is a new device that efficiently stimulates realistic vibration in flight vehicles. The stimulus is repetitive impacts by small projectiles on the surface of the test vehicle. The nature of these impacts is random with respect to the relative location, time interval and intensity between successive impacts. The resultant vehicle vibration resembles that of flight with the characteristics of broad band random noise motion, in many directions, throughout the vehicle structure.

81-2236

Vibration Qualification of Equipment Mounted in Turboprop Aircraft

L.G. Smith

Hughes Aircraft Co., Fullerton, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 69-72 (May

1981) 2 figs, 1 table (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Aircraft equipment response, Vibration tests

A test program required the derivation and implementation of environmental criteria for qualification of equipment mounted in turboprop aircraft. This paper discussed the vibration portion of the progra Both the criteria and the test control methods are unique and are applicable to other programs for qualifying equipment for the turboprop aircraft vibratory environment.

81-2237

Vibration Test Level Criteria for Aircraft Equipment

P.S. Hall

Flight Dynamics Lab., Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 81-91 (May 1981) 6 figs, 4 tables, 12 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Vibration tests, Testing techniques, Aircraft

The Combined Environment Reliability Test (CERT) Evaluation Program, conducted by the Air Force Wright Aeronautical Laboratories (AFWAL), utilized different methodologies to formulate the vibration test conditions. The problems of mission profiling the vibration environmental stresses are varied. Each methodology is examined for ease of vibration test condition formulation, utilization, and resultant reliability of the specimens tested. A recommendation is made on vibration test criteria for CERT based upon five years of experience and test results.

81-2238

Parameters for Design of Reverberant Acoustic Chambers for Testing Air-Carried Missiles

T.W. Elliott

Pacific Missile Test Center, Point Mugu, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 31-39 (May 1981) 3 figs, 3 tables, 4 refs (51st Symp. Shock Vib., San Diego, CA Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Test facilities, Reverberation chambers, Normal modes, Vibration tests, Optimum design, Missiles

Rectangular box-shaped reverberant acoustic chambers were theoretically analyzed, using a normal-mode model, for the purpose of optimal design for simulating captive flight vibration of air-carried missiles. A mathematical derivation relating chamber volume to minimum usable frequency was derived. It was determined that minimum usable frequency varied inversely as the square root of the volume ratios. A computer program was generated to investigate the important parameters for design of these chambers. It was found that, apart from some general rules-of-thumb to avoid in acoustic chamber design, there was no over-riding reason to select one configuration over another.

81-2239

Natural Frequency Analysis of Coupled Elastic Structures (Eigenschwingungsanalyse gekoppelter elastischer Strukturen)

K.-J. Schmidt

Institut f. Mechanik, Universität Hannover, Germany, Fortschritt-Berichte VDI-Z., Series 11, No. 39, 114 pp (1981) 37 figs, 11 tables. Summarized in VDI-Z., 123 (6), p 290 (Apr 1981) Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Düsseldorf 1, Germany, Price: 38 DM

(In German)

Key Words: Component mode synthesis, Natural frequencies, Rotors, Blades

A new technique for the vibration analysis of complicated structures, such as bladed rotors, is described. The technique is based on a type of component synthesis method -- the so called free interface method -- and is an extension of Craig's procedure. It allows coupling of several adjacent substructures. For the application of this method a computer program was developed which is more efficient and economical than present programs. As an example a simplified bladed disk is analyzed experimentally and theoretically and the results are compared.

81-2240

A Comparison of Multifrequency Techniques for Measuring the Dynamics of Squeeze-Film Bearings

C.R. Burrows, R. Sayed-Esfahani, and R. Stanway

School of Engrg. and Appl. Sciences, Univ. of Sussex, Falmer, Brighton, UK, J. Lubric. Tech., Trans. ASME, 103 (1), pp 137-143 (Jan 1981) 9 figs, 14 refs

Key Words: Bearings, Squeeze-film bearings, Multifrequency testing techniques, Testing techniques

The use of Schroeder-phased harmonic signals for multifrequency testing of squeeze-film bearings is considered by presenting some results obtained from a model bearing. The results are compared with those obtained using pseudorandom binary sequence forcing. The relative merits of these two forms of multifrequency excitation are discussed.

81-2241

Laboratory Vibration Schedules

Army Test and Evaluation Command, Aberdeen Proving Ground, MD, Rept. No. TOP-1-2-601, 35 pp (Dec 22, 1980)
AD-A093 705

Key Words: Vibration tests, Transportation effects, Equipment response, Flight vehicle equipment response, Ground vehicle equipment response

This report provides schedules for conducting laboratory vibration tests of Army material and discusses selection of schedules. Covered are simulated logistical transportation of secured cargo, and tactical transportation of equipment installed in ground vehicles and helicopters and mounted externally on helicopters. Schedules include vibration levels, frequencies, and test time for various simulations. It is applicable to ammunition (including close support rockets and missiles) and to electronic, mechanical, and optical equipment.

81-2242

Optimizing Pre and Post Pulses for Shaker Shock Testing

R.T. Fandrich
Harris Corporation, Melbourne, FL, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 1-13 (May 1981) 11 figs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shakers, Shock tests, Pulse test method

The method of selecting pre and post pulses described in this paper considers the entire pulse must fit the required tolerances, the optimum initial conditions must exist before the test pulse starts, including optimum velocity, displacement and acceleration, the terminal acceleration, velocity and displacement must be zero and the excursions of acceleration, velocity and displacement must fall within the shaker system capability. In order to simultaneously consider these four requirements, a computer program was written to generate various shaped pre and post pulses. These shapes were mathematically integrated to find the velocity and displacement profiles, which could then be compared to the requirements. Parametric variation was performed to optimize the shapes.

81-2243

Development of a Multiaxial Force-Pulse Generator

R.D. Crowson, F.B. Safford, W.J. Schuman, Jr., and R. Freiberg
U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 59-68 (May 1981) 15 figs, 1 table, 4 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Force generators, Shock tests, Equipment response, Nuclear weapons effects

U.S. Army mobile tactical communication systems, typically housed in shelters on trucks, may be loaded substantially from the airblast produced by high explosive or nuclear weapons. A laboratory simulation device capable of generating specified force-time histories could be used to subject the equipment to loads as might be encountered in a battlefield condition. Such a device has been developed with a capability of producing rectangular force pulses along two axes in excess of 45 kN. Calibration of the force pulser and initial biaxial tests using a simulated mass in lieu of actual radio equipment have been conducted. Such tests clearly demonstrate the feasibility of the system's usefulness in subjecting equipment to force-time histories having both the amplitude and frequency content of those measured in high explosive field tests.

81-2244

EDESS: An Electromagnetically-Driven Explosive-Shock Simulator

F.J. Sazama and J.B. Whitt
Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 137-147 (May 1981) 12 figs, 2 tables, 9 refs (51st Symp. Shock Vib.,

San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Force generators, Shock tests

A new series of electromagnetically-driven shock generators called EDESS is being evaluated at the Naval Surface Weapons Center for generating explosive-like shocks. A prototype generator, EDESS-1, has been built and its performance has been evaluated using 1.0 and 2.0 metric ton payloads. Presently, a larger generator, EDESS-2, is being built to extend the payload capability to 5.0 metric tons and a homopolar-driven generator, EDESS-3, is being contemplated for 15.0 metric ton payloads. This paper presents the electromagnetic shock-generation concept and reviews the progress made in developing these heavy payload shock generators.

81-2245

Feasibility Study for the Surface Impulse Loading of Structures Using Mild Detonating Fuze

D.L. Shirey and F.H. Mathews

Sandia Natl. Labs., Explosives Testing Organization 1533, Albuquerque, NM 87185, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 177-187 (May 1981) 21 figs, 2 tables, 11 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock test, Testing techniques

The possibility of impulsively loading the surface of large structures at relatively low impulse levels by using Mild Detonating Fuze (MDF) has been studied. The impulse is obtained when a metal spray driven by detonation of the MDF explosive core strikes an adjacent target resulting in momentum transfer to the target surface. The performance of two common types of MDF has been measured. Possible interactions between two parallel, detonating strands of MDF have been observed and found to be insignificant. Experimental results are compared. The impulse imparted to flat plate targets was observed using a pulse radiographic technique. Then these results were compared to a computational model which treats the target-spray interaction as an inelastic impact, reasonable agreement was obtained for the normal component of impulse.

81-2246

A Theory for the Calculation of Explosive Deposition Profiles from the Spray Painting of Light Initiated Explosive

F.H. Mathews

Sandia Natl. Labs., Albuquerque, NM 87185, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 189-204 (May 1981) 13 figs, 10 tables, 11 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock tests, Testing techniques, Weapons systems, Vulnerability

When a weapon structure is exposed to X-rays, the energy deposited in the surface material may result in an impulsive pressure loading on the surface. Laboratory nuclear effects experimentation allow the study of structural response during simulation tests. Spray painted coatings of Silver Acetylide-Silver Nitrate explosive when surface initiated by an intense flash of light provide a suitable test loading. Safety considerations dictated by the initiation sensitivity of this primary explosive require that the spray process be carried out by remote control. The ability to predict deposition during design of the spray procedure is therefore important in developing an efficient and safe technique. The processes occurring during spray painting of the explosive layer on the target surface were studied and an empirical theory of spray deposition developed.

81-2247

A Large-Scale Submarine Shock Test Carried Out as Part of the Swedish Shock Design Development Program

K. Hellqvist

Kockums AB, Malmo, Sweden, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 129-136 (May 1981) 8 figs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock tests, Submarine hulls

The paper describes the detonation tests carried out in 1978 with a test body called the 'Steel Mosquito', a full scale section of a submarine hull. A test site was arranged in the Stockholm Archipelago and the test body was moored at a depth of approximately 90 m (300 ft). The purpose of the tests were to investigate various outfits for submarines and to obtain data to be used when designing outfits and equipment for submarines as well as for further development work.

81-2248

A Computer-Controlled Measuring System Having

128 Analog Measuring Channels and Facilities for Signal Analysis
K. Hellqvist
Kockums AB, Malmö, Sweden, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 121-128 (May 1981) 6 figs, 2 tables (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock tests, Submarine hulls, Computer-aided techniques, Measurement techniques, Measuring instruments

When explosion testing the submarine hull section 'Steel Mosquito' in 1978 measurements were carried out using a computer-controlled digital measuring system. The system was chiefly designed for explosion test measurements but it can also be used for various types of vibration measurements. At present the system is capable of handling 128 simultaneous signals but it can be extended to 224 channels. After completed measurements the computer can be used for signal analysis of the measurements. Programs have been worked out for both signal analysis and modal analysis. The paper describes the system as used with the explosion tests in 1978.

81-2249
Conservatism in Least Favorable Response Analysis and Testing
T.L. Paez
The Univ. of New Mexico, Albuquerque, NM 87131, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 2, pp 93-109 (May 1981) 13 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock tests, Least favorable response method

A structural shock test is conservative when it excites a more severe response than the input which it is meant to represent. Shock signals from random sources in the field can be measured and used to generate a shock test. If a structure survives this test then there is some probability that it would survive shocks generated by the random field sources in the future. This probability depends on the random shock sources and the degree of conservatism inherent in the shock test specification technique. In this paper a procedure for computing the probability of shock test conservatism for tests generated using the method or least favorable response is demonstrated. Several numerical examples are presented.

SCALING AND MODELING

81-2250
Similitude Analysis and Testing of Prototype and 1:13.8 Scale Model of an Offshore Platform
C.S. Li, C.S. Yang, N.G. Dagalakis, and W. Messick
Mech. Engrg. Dept., Univ. of Maryland, College Park, MD 20742, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 195-216 (May 1981) 13 figs, 6 tables, 7 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Off-shore structures, Simulation, Scaling

The purpose of this investigation was to determine the dynamic similitude laws between a prototype offshore platform and its scale model and to investigate the accuracy of these laws and the effects of practical modeling assumptions with the use of finite element dynamic models of the platform and model. In order to derive the scaling parameters for the modeling of the offshore platform, deep cantilever beam equations with hydrodynamic loading similar to the one acting on a circular cylindrical pile were used. Eleven scaling parameters were obtained for the dimensional analysis and from these parameters eight dimensionless groups and corresponding scaling equations were derived. The results of this analysis were applied to the design of an 1:13.8 scale model of an existing four legged oil platform. The accuracy of the dynamic similitude analysis was investigated with finite element computer models of both the prototype and the 1:13.8 scale model. Dynamic characteristics of the prototype like eigenvalues, mode shapes and transient response were compared with those of the model, and the influence of the degree of detail of the finite element model on these characteristic responses was determined.

DIAGNOSTICS

81-2251
Estimation of Excitation and Transmissibility from Output Measurements, with Application to Gear Drives
K.J. Daly and J.D. Smith
Dept. of Engrg., Univ. of Cambridge, Cambridge CB2 1PZ, UK, J. Sound Vib., 75 (1), pp 37-50 (Mar 8, 1981) 10 figs, 1 table, 8 refs

Key Words: Gear drives, Failure analysis, Diagnostic techniques

Methods are presented by which both harmonic input magnitudes and dynamic transmissibility can be estimated when only the output of a system can be measured. This is possible when the input to a system consists of components whose amplitude remains constant although their time scale changes with speed. An example of this occurs with gear induced vibration where the forcing function is provided by errors which remain constant in amplitude. Examples given show how the methods can be used to estimate the static transmission error components of gear drives from dynamic response measurements where drive speeds are restricted.

BALANCING

81-2252

Method to Calculate the Balancing System of a Three-Cylinder Diesel Engine

G. Radnoti

Flying Tiger Line, Kennedy Intl. Airport, Jamaica, NY, ASME Paper No. 81-DGP-8

Key Words: Balancing techniques, Diesel engines

A unique balancing system was introduced by General Motors for its two cycle Series 71 diesel engines. This paper presents an analysis for this balancing system, and shows how this balancing problem can be attacked by various methods of calculation.

81-2253

A Computerized Balancing Technique for Supercritical Helicopter Shafting

G.J. Korkosz

Hughes Helicopters, Culver City, CA, Rept. No. HH-80-223, USAAVRADCOM-TR-80-F-15, 55 pp (Dec 1980)

AD-A095 143

Key Words: Balancing techniques, Computer-aided techniques, Shafts, Helicopters

A full-size supercritical helicopter tail rotor drive shaft has been balanced using a quasi-static data acquisition technique. The method employs ultrasonic gaging equipment and a digital computer to determine the amount and location of the balance correction. In one 15-minute pass, the system has demonstrated the ability to locate the center of gravity of the shaft within 0.001 inch. The balanced shaft has run at speeds up to 10,500 rpm, including sustained operation at four critical speeds, with acceptable vibration at critical speeds. Operation at the design speed (between 2nd and 3rd critical speed) was well within standard high quality balance values.

MONITORING

(See No. 2289)

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see Nos. 2054, 2185, 2205, 2206)

81-2254

An Evaluation of: Doubly Asymptotic Approximation; Staggered Solution Schemes; USA-STAGS

R.S. Dunham, R.J. James, A.S. Kushner, and D.E. Ranta

Pacifica Technology, San Diego, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 133-172 (May 1981) 4 figs, 42 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shells, Submerged structures, Acoustic excitation, Interaction: structure-fluid, Doubly asymptotic approximation method, Staggered solution schemes, STAGS (computer program), USA (computer program)

This report presents a comprehensive review and evaluation of the doubly asymptotic approximation and the staggered solution scheme implemented in the USA-STAGS computer codes. The equations are derived and discussed in detail. Various solution strategies are examined. A stability analysis of the staggered scheme and a fully implicit integration scheme is done using the Lax-Richtmyer approach. Solutions to several problems are presented and comparisons made to closed form solutions. Detailed conclusions and recommendations are made, and appendices provide a list of errors and recommended improvements in both the USA and STAGS codes.

81-2255

Stability of Some Explicit Difference Schemes for Fluid-Structure Interaction Problems

H. Neishlos, M. Israeli, and Y. Kivity

Dept. of Computer Science, Technion-Israel Inst. of Tech., Haifa, Israel, Computers Struc., 13 (1-3), pp 97-101 (June 1981) 4 figs, 1 table, 8 refs

Key Words: Interaction: structure-fluid, Submarines, Underwater explosions

The spectral stability theory of initial boundary value explicit finite-difference schemes is used to develop a stability analysis method for problems of fluid-structure interaction. By this analysis it is shown that due to the interaction between the structure and fluid stability restrictions on the time step may be more severe than commonly assumed. Four schemes of practical interest are analyzed in detail. The validity of the stability analysis is tested by simulating the effects of underwater explosion on a submarine. The computational results corroborate the prediction of the analysis concerning the stability boundary.

81-2256

A Family of Early-Time Approximations for Fluid-Structure Interaction

C.A. Felippa

Applied Mechanics Lab., Lockheed Palo Alto Res. Lab., Palo Alto, CA 94304, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 703-708 (Dec 1980) 6 figs, 1 table, 16 refs

Key Words: Interaction: fluid-structure, Approximation methods, Submerged structures, Acoustic impedance

A hierarchical family of early-time, high-frequency asymptotic, surface interaction approximations is derived for a structure submerged in an infinite acoustic fluid. Kirchoff's retarded-potential integro-differential formulation is used as exact source formula. The well-known plane-wave and curved-wave approximations result as the first two members of the hierarchy. Acoustic impedance characteristics of the first four members are exhibited for several sample geometries.

81-2257

Rationale for a Linear Perturbation Method for the Flow Field Induced by Fluid-Structure Interactions

A.A. Sonin

Dept. of Mech. Engrg., Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 725-728 (Dec 1980) 2 figs, 5 refs

Key Words: Interaction: structure-fluid, Perturbation theory

A formal justification is developed for a method in which hydrodynamic data for a transient in a rigid-wall system (derived, for example, from a small-scale experimental simulation) is used as input in a linear computation for the perturbation flow field due to actual wall flexibility. The method is useful in problems where the basic flow transient is so complex that it can be quantified only empirically, and where the fluid-structure interaction is too complex for the fluid side to be represented by a priori defined equivalent mass.

81-2258

Media-Structure Interaction Computations Employing Frequency Dependent Mesh Sizes with the Finite Element Method

A.J. Kalinowski and C.W. Nebelung

Naval Underwater Systems Ctr., New London, CT, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 173-193 (May 1981) 17 figs, 2 tables, 13 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Interaction: structure-medium, Interaction: structure-fluid, Moving loads, Transient response, Finite element technique, Frequency domain method

The general problem of treating the numerical linear dynamic response of structures imbedded in a medium (fluid or solid) while subject to either radiation conditions or incident traveling wave inputs is considered. The formulation models both the imbedded structure and surrounding medium with finite elements and treats the absorption of waves radiated outward from the structure by means of appropriately sized dampers. Transient solutions are obtained by first computing the steady state transfer function for the response quantity of interest, and later post-processing this function with an FFT algorithm in conjunction with the specific input wave form. Segments of the transfer function are computed with the finite element method in the frequency domain by employing a set of frequency dependent mesh size finite element models, carefully designed to operate over a limited frequency band. The entire transfer function is obtained by piecing together the individual segments.

81-2259

Response of Stochastic Linear System

J. Szopa

Inst. of Theoretical Mechanics, Dept. of Math. and Physics, Silesian Technical Univ., Gliwice, Poland, ASCE J. Engrg. Mechanics Div., 107 (1), pp 1-11 (Feb 1981) 3 figs, 19 refs

Key Words: Covariance functions, Stochastic processes, Random excitation

A method is presented for determining the covariance function of response of a stochastic linear system in which coefficients and excitation are stochastic processes. Such a system is described by differential equations whose solution was searched for by means of perturbation method confined to the first approximation. These equations were converted into stochastic, integral Volterra equations of the second kind. Both the formula for covariance function of solution of the considered equation and the formula for the function of central moments of rth order of solution were calculated. The suggested method was verified numerically by computing the variance of response of a dynamical system with random variable mass for two types of stochastic excitations.

81-2260

Stochastic Analysis of Elasto-Plastic Systems

R.L. Grossmayer

Vienna Inst. of Tech., Karlplatz 13, A-1040 Vienna, Austria, ASCE J. Engrg. Mechanics Div., 107 (1), pp 97-116 (Feb 1981) 8 figs, 20 refs

Key Words: Stochastic processes, Random excitation, Elasto-plastic properties

A new approximate and simple technique is presented for predicting the response of elasto-plastic type yielding systems under stationary random excitation. The total response is split into a low frequent drift response and a remaining process, the behavior of which is determined by effective damping and stiffness parameters. These parameters are defined on the basis of open loop properties. A new estimate of the yield increment is proposed. It is computed iteratively. The procedure is applicable for white noise as well as filtered noise input spectra. Correction factors are introduced to account for the variability of the input energy with frequency. The results for the yield increment, the effective parameters, the steady-state and transient response statistics, and the ductility ratios show a generally good agreement with simulation estimates.

81-2261

An Instability Theorem for Steady Motions in Free and Restrained Dynamical Systems

P. Hagedorn and W. Teschner

Institut f. Mechanik, 61 Darmstadt, Hochschustrasse 1, Technische Hochschule Darmstadt, W. Germany, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 908-912 (Dec 1980) 3 figs, 8 refs

Key Words: Stability, Dynamic systems

The stability of steady motions in dynamical systems with ignorable coordinates is considered. In addition to the original "free" systems "restrained" systems are defined in such a way that the ignorable velocities remain constant along all motions; the stability behavior of the two systems is compared. A previously established instability theorem is generalized and three examples are given.

81-2262

A Theory of Cell-to-Cell Mapping Dynamical Systems

C.S. Hsu

Dept. of Mech. Engrg., Univ. of California, Berkeley, CA 94720, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 931-939 (Dec 1980) 6 figs, 14 refs

Key Words: Cell-to-cell mapping, Dynamic systems

The method of point-to-point mappings has been receiving increasing attention in recent years. In this paper dynamical systems governed by cell-to-cell mappings are discussed. The justifications of considering such mappings come from the unavoidable accuracy limitations of both physical measurements and numerical evaluation. Because of these limitations one is not really able to treat a state variable as a continuum of points but rather only as a collection of very small intervals. The introduction of the idea of cell-to-cell mappings has led to an algorithm which is found to be potentially a very powerful tool for global analysis of dynamical systems. In this paper an introductory theory of cell-to-cell mappings is offered.

81-2263

An Unravelling Algorithm for Global Analysis of Dynamical Systems: An Application of Cell-to-Cell Mappings

C.S. Hsu and R.S. Guttalu

Dept. of Mech. Engrg., Univ. of California, Berkeley, CA 94720, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 940-948 (Dec 1980) 13 figs, 7 refs

Key Words: Global analysis, Cell-to-cell mapping, Dynamic systems

A new method is offered for global analysis of nonlinear dynamical systems. It is based upon the idea of constructing the associated cell-to-cell mappings for dynamical systems governed by point mappings or governed by ordinary differential equations. The method uses an algorithm which allows us to determine in a very effective manner the equilibrium states, periodic motions and their domains of attraction when they are asymptotically stable. The theoretic base and the detail of the method are discussed in the paper and the great potential of the method is demonstrated by several examples of application.

81-2264

Experiments with Direct Integration Algorithms for Ordinary Differential Equations in Structural Dynamics

J. Braekhus and J.O. Aasen

Det norske Veritas, 1322 Høvik, Norway, Computers Struc., 13 (1-3), pp 91-96 (June 1981) 1 fig, 4 tables, 11 refs

Key Words: Differential equations, Integral equations, Dynamic structural analysis

Various explicit integration methods are compared with an implicit method on two dynamic problems in solid mechanics. Methods of steplength-control are discussed. Some effects of steplength-control on the behavior of explicit and implicit methods are pointed out and illustrated by the problems studied.

81-2265

Recent Advances in Reduction Methods for Nonlinear Problems

A.K. Noor

George Washington Univ. Ctr. at NASA Langley Res. Ctr., Hampton, VA 23665, Computers Struc., 13 (1-3), pp 31-44 (June 1981) 12 figs, 48 refs

Key Words: Reduction methods, Nonlinear theories

Status and some recent developments in the application of reduction methods to nonlinear structural mechanics problems are summarized. The aspects of reduction methods discussed herein include: selection of basis vectors in nonlinear static and dynamic problems, application of reduction methods in nonlinear static analysis of structures subjected to prescribed edge displacements, and use of reduction methods in conjunction with mixed finite element models. Numerical examples are presented to demonstrate the effectiveness of reduction methods in nonlinear problems. Also, a number of research areas which have high potential for application of reduction methods are identified.

81-2266

A Method of Order Reduction for Structural Dynamics Based on Riccati Iteration

L.R. Anderson and W.L. Hallauer, Jr.

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, AIAA J., 19 (6), pp 796-800 (June 1981) 6 figs, 2 tables, 14 refs

Key Words: Condensation method, Natural frequencies, Mode shapes

This paper presents a new method of order reduction based on recent work of a similar nature applicable to system dynamics and control. This method provides a computational procedure for producing a condensed model which exactly preserves the slowest modes of the total modes of the original model for almost any number of degrees of freedom retained in the condensed model. The method can also be used to compute the eigensolutions corresponding to the slowest modes of the original structural dynamics problem. The accuracy of the condensed model and the speed/accuracy performance of the eigensolver are compared with standard methods for a 90 degree-of-freedom cantilevered plate.

81-2267

A Method for Estimating the Error Induced by the Guyan Reduction

G.L. Fox

NKF Engineering Associates, Inc., Vienna, VA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 19-24 (May 1981) 1 fig, 4 tables, 2 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Modal analysis, Reduction methods, Error analysis

The Guyan Reduction refers to a method used to reduce the number of degrees of freedom in a structural model for dynamic analysis. Experience has shown that, if the method is properly employed, then this reduction method does in fact provide a reasonably accurate approximation of the dynamic characteristics of the unreduced model. To date, however, a cost (or computer time) effective method to estimate the actual error induced by the reduction process was not available. This paper presents an accurate and cost effective method to evaluate this error.

81-2268

Study of Guyan Reduction of Two Degrees of Freedom Systems

F.H. Wolff, A.J. Molnar, and J.A. Gribik
Westinghouse R&D Center, Pittsburgh, PA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 11-18 (May 1981) 9 figs, 4 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Modal analysis, Reduction methods, Error analysis

This paper evaluates errors in matching the 1st mode frequency and shape of a 2 mass model when a Guyan Reduction is applied to the model.

81-2269

Effective Dynamic Reanalysis of Large Structures

B.P. Wang and F.H. Chu
Univ. of Virginia, Charlottesville, VA 22901, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 73-79 (May 1981) 3 figs, 2 tables, 4 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Natural frequencies, Structures, Modification effects

This paper describes an effective dynamic reanalysis method which can be used to estimate the new natural frequencies of the structure after modification using the modal information of the original structure (i.e., natural frequencies, mode shapes at the location of the changes, and the generalized mass for each of the modes). A nonlinear algebraic equation is derived and by solving this equation using either the Newton Raphson's iteration method or simply the bisection method will give the new natural frequencies of the structure after modification. This method can be applied to the change of a linear spring, a concentrated mass, an extension member, a beam, and a plate element. A group change of the above mentioned elements can be achieved by solving a set of coupled nonlinear algebraic equations.

81-2270

Asymptotic Integration Methods Applied to Rotating Beams

C.R. Steele and K.E. Barry
Appl. Mechanics Div., Stanford Univ., Stanford, CA 94305, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 884-890 (Dec 1980) 4 figs, 3 tables, 18 refs

Key Words: Beams, Rotating structures, Integral equations

The in-plane vibrational characteristics of an off-axis clamped beam subjected to either compressive or tensile forces arising from steady rotation are studied. The differential equations of motion are cast into state vector form and solved using asymptotic matrix integration methods. The general theory of these methods is described in this paper and their application to the analysis of rotating beams is made. The advantages inherent in these methods with regard to accuracy, reduction of analytical complexity, and savings in computational costs are discussed.

81-2271

Partitioned Transient Analysis Procedures for Coupled-Field Problems: Accuracy Analysis

K.C. Park and C.A. Felippa
Appl. Mechanics Lab., Lockheed Palo Alto Res. Lab., 3251 Hanover St., Palo Alto, CA 94304, J. Appl. Mechanics, Trans. ASME, 47 (4), pp 919-926 (Dec 1980) 4 figs, 6 tables, 11 refs

Key Words: Transient response

Partitioned solution procedures for direct time integration of second-order coupled-field systems are studied from the standpoint of accuracy. These procedures are derived by three formulation steps: implicit integration of coupled governing equations, partitioning of resulting algebraic systems and extrapolation on the right-hand partition. It is shown that the combined effect of partition, extrapolation, and computational paths governs the choice of stable extrapolators and preservation of rigid-body motions. Stable extrapolators for various computational paths are derived and implementation-extrapolator combinations which preserve constant-velocity and constant-acceleration rigid-body motions are identified. A spectral analysis shows that the primary error source introduced by a stable partition is frequency distortion. Finally, as a guide to practical applications, the advantages and shortcomings of five specific partitions are discussed.

81-2272

Dynamic Response Analysis of Some Complex

Mechanisms by Means of Matrices (Beiträge zur Analyse der Dynamischen Antwort)
M. Dranga and N.I. Manolescu
Institutul Politechnic Bucuresti, Splaiul Independentei 313, Sector 6, Bucuresti, 77206, Romania, Mech. Mach. Theory, 16 (3), pp 215-220 (1981) 5 figs, 5 refs
(In German)

Key Words: Mechanisms, Dynamic response, Matrix methods

In two previous papers the concept of transmission vector was defined and a numerical algorithm was presented for the dynamic response of plane mechanisms having one degree of freedom. This paper treats the problem of transmission vectors for plane, multiple-loop mechanisms. The method is applied to the problem of motion analysis for a complex mechanism having variable dimensions.

MODELING TECHNIQUES

(Also see Nos. 2167, 2219, 2283)

81-2273
Modeling of Nonholonomic Dynamic Systems with Applications
H. Hemami and F.C. Weimer
Dept. of Electrical Engrg., Ohio State Univ., Columbus, OH, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 177-182 (Mar 1981) 12 figs, 15 refs

Key Words: Mathematical models, Nonholonomic systems, Impact force, Coulomb friction

A feedback model of nonholonomically constrained dynamic system is presented with applications in analysis, control, and understanding of such systems under impulsive and friction forces.

81-2274
On Nonlinear Dynamic Analysis Using Substructuring and Mode Superposition
K.-J. Bathe and S. Gracewski
Dept. of Mech. Engrg., Massachusetts Inst. of Tech., Cambridge, MA 02139, Computers Struc., 13 (5-6), pp 699-707 (Oct-Dec 1981) 10 figs, 9 refs

Key Words: Finite element technique, Substructuring methods, Modal superposition method

The solution of nonlinear dynamic equilibrium equations using mode superposition and substructuring is studied. The objective is to design schemes that in some analyses can significantly decrease the computational effort involved when compared to a complete direct integration solution. Specific schemes for mode superposition analysis and substructuring are proposed. These techniques have been implemented in ADINA. The results of a few sample analyses are presented and recommendations are given on the use of these procedures in practical analysis.

81-2275
Investigation of an Improved Flutter Speed Prediction Technique for Damaged T-38 Horizontal Stabilators Using NASTRAN
R.K. Thomson
Air Force Inst. of Tech., School of Engrg., Wright-Patterson AFB, OH, Master's Thesis, Rept. No. AFIT/GAE/AA/80D-21 (Dec 1980)
AD-A094 769

Key Words: Finite element technique, Mathematical models, Flutter, NASTRAN (computer programs), Computer programs

This thesis concerns the development of a finite element model of the T-38 horizontal stabilator for use on NASTRAN. The model is to be used to analyze degradations in flutter speed due to repair. Static analysis has shown the model to be lacking in torsional stiffness. The probable cause being the inability of NASTRAN plate bending elements to model torsion cells. An increase of elastic and shear moduli of plate bending elements in the model by 30 percent produced more accurate results but additional investigation is necessary. Modal analysis has pointed to a modeling error in the root, trailing edge area. A flutter analysis procedure was established and the effects of the errors found in the structural model were investigated. With no corrections made to the model, a flutter speed equivalent to that predicted using strip theory was achieved for the sea level condition.

STATISTICAL METHODS

81-2276
Monte Carlo Simulations of Responses of Non-Symmetric Dynamic System to Random Excitations
P-T.D. Spanos
Texas Inst. of Computational Mechanics, Univ. of

Texas, Austin, TX 78712, Computers Struc., 13 (1-3), pp 371-376 (June 1981) 10 figs, 21 refs

Key Words: Statistical analysis, Monte Carlo method, Random excitation, Nonlinear systems, Viscous damping, Equivalent linearization method

Numerical simulation data regarding the statistics of the response of a non-symmetric dynamic system are presented. A stationary and a modulated non-stationary white Gaussian process have been used as the excitations of the system. Non-stationary and stationary statistics of the system response are presented. The numerical data are used to extract information on the dependence of the response statistics on parameters such as the viscous damping and the magnitude of the nonlinearity of the dynamic system. Furthermore, they serve to examine the reliability of a random vibration analysis of the system, based on the technique of equivalent linearization.

PARAMETER IDENTIFICATION

81-2277

Input Identification from Structural Vibrational Response

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Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/26, NSF/RA-800295

PB81-152308

Key Words: Parameter identification technique, Frequency domain method

The equivalent linearization method is applied to input identification from known structural response and system parameters, working in frequency domain. In addition to the commonly used one-model procedure, a two-model input identification procedure is proposed. Numerical examples of structural systems having elements of bilinear force-deformation relations are presented for different cases of stiffness, input motion and level of nonlinearity. Structural response obtained from true hysteretic loop analyses are used as the known responses with the unknown input motions to be identified. These identified motions are then compared with the real motions to check agreement with their maximum accelerations, response spectra, Fourier amplitude spectra, and acceleration time-histories. Shaking table tests of two three-story braced steel frames are used as examples to check the accuracy of the suggested input identification procedure. The bracing systems used show strong nonlinearities due to buckling and material yielding. Sources of error in the analysis are discussed and possible improvements of the input identification procedure are suggested.

81-2278

The Identification of Amplitude-Dependent Aerodynamic Force Parameters and Their Use in the Stability Investigation of Aeroelastic Two Degree of Freedom Systems (Identifikation amplitudenabhängiger Luftkraftparameter und ihre Verwendung bei der Stabilitätsuntersuchung aeroelastischer Zwei-Freiheitsgrad-Systeme)

R. Oltmann

Institut f. Mechanik Universitat, Hannover, Germany, Fortschritt-Berichte VDI-Z., Series 4, No. 59, 96 pp (1981) 32 figs, 12 tables. Summarized in VDI-Z., 123 (6), p 302 (Apr 1981) Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Düsseldorf 1, Germany, Price: 57,-DM

(In German)

Key Words: Parameter identification technique, Amplitude data, Nonlinear theories

A modified aerodynamic force model for the prediction of structural vibrations is presented. The parameter matrices are dependent on the deflection vector. Using this nonlinear model not only the critical wind velocity is determined, but a corresponding amplitude for each wind velocity can be found. Thus the deflection of any part of the structure can be predicted.

81-2279

A Parametric Study of the Ibrahim Time Domain Modal Identification Algorithm

R.S. Pappa and S.R. Ibrahim

Structural Dynamics Branch, NASA Langley Res. Ctr., Hampton, VA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 3, pp 43-72 (May 1981) 14 figs, 3 tables, 12 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Parameter identification technique, Time domain method, Plates

The accuracy of the Ibrahim Time Domain identification algorithm in extracting structural modal parameters from free-response functions has been studied using computer-simulated data for 65 positions on an isotropic, uniform-thickness plate, with mode shapes obtained by NASTRAN analysis. Natural frequencies, damping factors, and response levels of the first 15 plate modes were arbitrarily assigned in forming the response functions, to study identification results over ranges of modal parameter values and user-selectable algorithm constants. Effects of superimposing various levels of noise onto the functions were investigated in detail. A particularly interesting result is that no detrimental effects were observed when the number of computational degrees-of-freedom allowed in the algorithm was made many times larger than the minimum necessary for adequate identification. This result suggests the use of a high number of degrees-of-freedom when analyzing experimental data, for the simultaneous identification of many modes in one computer run. Details of the procedure used for these identifications are included.

81-2280

Parameter Identification of Turborotors from Their Vibration Behavior (Zur Parameteridentifikation von Turboläufern aus dem Schwingungsverhalten)

V. Schlegel

Institut f. Mechanik, Universität Hannover, West Germany, Fortschritt-Berichte VDI-Z., Series 11, No. 35, 152 pp (1981) 37 figs. Summarized in VDI-Z., 123 (3), p 97 (Feb 1981) Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Düsseldorf 1, Germany, Price: 82.-DM

(In German)

Key Words: Parameter identification technique, Rotors Turbomachinery

A parameter identification method for turborotors in friction bearings is described. The method enables the calculation of the effects of unbalance and of initial deformation.

DESIGN TECHNIQUES

(Also see No. 2195)

81-2281

Experimental-Theoretical Analysis of Machine Vibrations (Experimentell-rechnerische Analyse von Maschinenschwingungen)

E.-K. Prössler

Laboratorium f. Werkzeugmaschinen und Betriebslehre Rheinisch-Westfalische Technische Hochschule Aachen, Fortschritt-Berichte VDI-Z., Series 11, No. 36, 144 pp (1981) 57 figs, 1 table. Summarized in VDI-Z., 123 (5), p 152 (Feb 1981) Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Düsseldorf 1, Germany, Price: 27,50 DM

(In German)

Key Words: Vibration measurement, Measurement techniques, Design techniques, Optimum design, Machinery, Parameter identification technique

Means for combining experimental results and mathematical calculations in the optimization of machinery design are described. The procedure enables the determination of the effects of structural changes made during the optimization of design on the behavior of machinery and reduces the chance of errors caused by some intuitively made changes.

COMPUTER PROGRAMS

(Also see Nos. 2120, 2125, 2254, 2275)

81-2282

NIKE3D: An Implicit, Finite Element Code for Analyzing the Static and Dynamic Response of Three-Dimensional Solids

J.O. Hallquist

Lawrence Livermore Lab., Univ. of California, Livermore, CA, Rept. No. UCID-18822, 56 pp (Jan 1981)

Key Words: Computer programs, Finite element technique, Three dimensional problems

A user's manual is provided for NIKE3D, a fully implicit three-dimensional finite element code for analyzing the large deformation static and dynamic response of inelastic solids. A contact-impact algorithm permits gaps and sliding along material interfaces. By a specialization of this algorithm, such interfaces can be rigidly tied to admit variable zoning without the need of transition regions. Spatial discretization is achieved by the use of 8-node constant pressure solid elements. Bandwidth minimization is optional. Post-processors for NIKE3D include GRAPE for plotting deformed shapes and stress contours and DYNAP for plotting time histories.

81-2283

Survey of Computer Programs for Solution of Nonlinear Structural and Solid Mechanics Problems

A.K. Noor

George Washington Univ. Ctr. at NASA Langley Res. Ctr., Hampton, VA 23665, Computers Struc., 13 (1-3), pp 425-465 (June 1981) 98 refs

Key Words: Computer programs, Finite element technique, Reviews

This paper gives an overview of the current capabilities of thirty-six finite element computer programs that can be used for solution of nonlinear structural and solid mechanics problems. These programs range from the large, general purpose codes with a broad spectrum of capabilities, rich variety of element types, larger user community, and comprehensive user support (e.g. ANSYS, ASAS-NL, ASKA, MARC, MSC/NASTRAN and SESAM-69) to the small, special purpose codes with limited user community such as BEAM, BRICK, PAC78 and WHAMS. The capabilities of the programs surveyed are listed in tabular form followed by a summary of the major features of each program. It is anticipated that this format will help in the initial selection of programs which are most suitable for a particular application. Before listing the capabilities of the programs, some of the sources of information about computer programs and references on the background material needed for effectively using the programs are listed, and guidelines for selecting the code are discussed.

81-2284
Probabilistic Dynamic Analysis with ADINA
D.D. Pfaffinger
FIDES Trust Co., Zurich, Switzerland, Computers Struc., 13 (5-6), pp 637-646 (Oct-Dec 1981) 7 figs, 1 table, 10 refs

Key Words: Computer programs, Probability theory, Random excitation

In structural analysis the extreme values of the structural response quantities are of primary interest. In the case of linear structures under stationary Gaussian random excitations a probabilistic analysis provides the expected extreme values as well as confidence intervals in a mathematically rigorous way. The analysis becomes particularly simple in modal coordinates, if the damping matrix decouples. All quantities required for the probabilistic analysis are then readily obtained from the modal covariance matrices. The evaluation of these matrices by analytical integration is discussed. This method is computationally very effective and maintains full accuracy in the dynamic properties of the structural model. The implementation of the probabilistic analysis in ADINA is outlined. As an illustration, the seismic analysis of a structure under multiple support random excitation is presented.

81-2285
Fluid Structure Coupling Algorithm
W.H. McMaster, E.Y. Gong, C.S. Landram, and D.F. Quinones
Univ. of California, Lawrence Livermore Lab., P.O. Box 808, Livermore, CA 94550, Computers Struc., 13 (1-3), pp 163-166 (June 1981) 10 refs

Key Words: Interaction: structure-fluid, Computer programs

A fluid-structure-interaction algorithm has been developed and incorporated into the two dimensional code PELE-IC. This code combines an Eulerian incompressible fluid algorithm with a Lagrangian finite element shell algorithm and incorporates the treatment of complex free surfaces. The fluid structure and coupling algorithms have been verified by the calculation of solved problems from the literature and from air and steam blowdown experiments. The code has been used to calculate loads and structural response from air blowdown and the oscillatory condensation of steam bubbles in water suppression pools typical of boiling water reactors. The techniques developed here have been extended to three dimensions and implemented in the computer code PELE-3D.

81-2286
Computational Method for Soil/Structure Interaction Problems
Y.M. Ito, R.H. England, and R.B. Nelson
California Research and Tech., Inc., Woodland Hills, CA, Computers Struc., 13 (1-3), pp 157-162 (June 1981) 9 figs, 5 refs

Key Words: Interaction: soil-structure, Reinforced concrete, Computer programs

This paper describes a computational method for soil/structure interaction problems, with particular emphasis on reinforced concrete structural response. The computational method involves the modeling capabilities of the CRT/NONSAP finite-element computer code which has been extended to address soil/structure interaction problems. Some of the relevant improvements include: refined elastic-plastic material models for concrete and geologic materials, interface element to model shear transfer and sliding at soil/structure interfaces, and element deletion (removal) procedure for representation of cracking in brittle materials, or failure in ductile material caused by large strains. The details of these improvements regarding their applicability to dynamic analysis of reinforced concrete structures and the effects of soil/structure interaction are described. Also, the nonlinear response analysis of a buried reinforced concrete cylinder to an air blast environment is presented.

GENERAL TOPICS

TUTORIALS AND REVIEWS

(Also see No. 2160)

81-2287

Necessary and Sufficient Qualification for Shock

R. Dyrdahl

The Boeing Company, Seattle, Washington, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 47-50 (May 1981) 3 figs, 1 table (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Testing techniques, Test equipment and instrumentation, Vibration tests, Shock tests, Specifications

The author describes the drawbacks resulting from the lack of unified concise procedures and guidelines for necessary and sufficient analysis, and test of equipment exposed to shock and vibration. He challenges the Shock and Vibration Center to undertake the task.

81-2288

An Approach to the Limitation and Control of Shipboard Vibration

E.F. Noonan

NKF Engineering Associates, Inc., Vienna, VA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 51, Pt 1, pp 3-13 (May 1981) 6 figs, 37 refs (51st Symp. Shock Vib., San Diego, CA, Oct 21-23, 1980. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Ships, Vibration control, Reviews, Specifications

A history of vibration control technology aboard ship is presented, beginning with vibrations caused by mechanical propulsion systems and the vulnerability of ships to underwater explosions during World War II. The most significant early post World War II studies are described and the publications resulting from these studies are listed. An approach in the preliminary design phase, which would permit a reasonable prediction of anticipated vibration characteristics of the hull and main machinery system is described. Various codes and specifications pertinent to the approach are listed.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(Also see No. 2288)

81-2289

Proposed Recommended Practices in Applying Broadband Vibration Screening to Electronic Hardware

W. Silver

Shock and Vibration Comm., Westinghouse Electric Corp., MS 504, P.O. Box 746, Baltimore, MD 21203, J. Environ. Sci., 24 (1), pp 9-11 (Jan-Feb 1981) 1 table, 5 refs

Key Words: Failure detection, Vibratory techniques, Testing techniques, Test specifications, Specifications

The effectiveness of vibration stress screening of electronic hardware is strongly dependent on the structural nature of the hardware being screened and on the nature of the included defects. If cost-effective vibration screening is to be developed, screening procedures must be related to hardware level of assembly. This set of recommended practices has been developed to guide the use of broadband vibration screening of a broad range of conventionally designed hardware. While it is recognized that certain rare cases may exist where its use is unsuitable, it is intended to be generally applied unless it can be shown to be damaging to fault-free hardware.

AUTHOR INDEX

TECHNICAL NOTES

A. Krishnan and S.C. Rajan
A Note on Resonance
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N. Eddington and I. Eddington
Attenuation of Noise at the Point of Perception: A New Look at a Least Preferred Strategy
J. Sound Vib., 72 (3), pp 423-426 (Oct 8, 1980)
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T. Sakata and Y. Sakata
Vibrations of a Taut String with Stepped Mass Density
J. Sound Vib., 71 (2), pp 315-317 (July 22, 1980)
1 table, 2 refs

P.B. Joshi and J.A. Schetz
The Rigid-Wavy-Wall Assumption in Interface Stability Problems
J. Appl. Mechanics, Trans. ASME, 47 (4), pp 949-951 (Dec 1980) 1 fig, 1 table, 15 refs

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Transient Analysis of Stress Waves Around a Rectangular Crack under Impact Load
J. Appl. Mechanics, Trans. ASME, 47 (4), pp 958-959 (Dec 1980) 3 figs, 1 table, 6 refs

B.M. Singh, J.B. Haddow, J. Vrbik, and T.B. Moodie
Dynamic Stress-Intensity Factors for Penny-Shaped Crack in Twisted Plate
J. Appl. Mechanics, Trans. ASME, 47 (4), pp 963-965 (Dec 1980) 2 figs, 3 refs

C.-Y. Wang and L.T. Watson
Theory of the Constant Force Spring
J. Appl. Mechanics, Trans. ASME, 47 (4), pp 956-957 (Dec 1980) 2 figs, 4 refs

P.H. Markho
On Free Vibrations with Combined Viscous and Coulomb Damping
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G.R. Bhashyam and G. Prathap
Non-Linear Vibration Behaviour of Beams with Elastic Rotational Restraints
J. Sound Vib., 74 (1), pp 148-150 (Jan 8, 1981)
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C. Venkatesan and V.T. Nagaraj
On the Axial Vibrations of Rotating Bars
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G.V. Rao and R. Narayanaswami
Optimization of Simply Supported Beams in Large Amplitude Vibration Subject to a Frequency
J. Sound Vib., 74 (1), pp 139-142 (Jan 8, 1981)
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G.K. Ramaiah
Natural Frequencies of Spinning Annular Plates
J. Sound Vib., 74 (2), pp 303-310 (Jan 22, 1981)
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R.W. Fearn
Generalization of the Method of Slowly Varying Amplitude and Phase to Non-Linear Oscillatory Systems with Two Degrees of Freedom
J. Sound Vib., 74 (3), pp 455-458 (Feb 8, 1981)
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P.N. Singh, Y.C. Das, and V. Sundararajan
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Planar Motion of a Rigid Body with a Friction Rotor
J. Appl. Mechanics, Trans. ASME, 48 (1), pp 205-206 (Mar 1981) 2 figs, 4 refs

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J. Appl. Mechanics, Trans. ASME, 48 (1), pp 200-203 (Mar 1981) 1 fig, 10 refs

CALENDAR

NOVEMBER 1981

9-12 Truck Meeting & Exposition [SAE] Dearborn, MI *(SAE Hqs.)*

15-20 ASME Winter Annual Meeting [ASME] Washington, DC *(ASME Hqs.)*

16-19 Intl. Pacific Conference on Automotive Engineering [SAE] Honolulu, Hawaii *(SAE Hqs.)*

17-19 Technical Diagnostics Symposium [IMEKO Technical Committee on Technical Diagnostics] London, England *(Institute of Measurement and Control, 20 Peel St., London W8 7PD, England)*

18-20 Fourth SAE Intl. Conference on Vehicle Structural Mechanics [SAE] Detroit, MI *(SAE Hqs.)*

30-Dec 4 Acoustical Society of America, Fall Meeting [ASA] Miami Beach, FL *(ASA Hqs.)*

DECEMBER 1981

1-3 10th Turbomachinery Symposium [Texas A&M University] Houston, TX *(Peter E. Jenkins, Director, Turbomachinery Labs., Dept. of Mech. Engrg., Texas A&M Univ., College Station, TX 77843 - (713) 845-7417)*

1-3 Automotive Plastics Durability Conference and Exposition [SAE] Troy, MI *(SAE Hqs.)*

8-10 Western Design Engineering Show [ASME] Anaheim, CA *(ASME Hqs.)*

FEBRUARY 1982

22-26 SAE Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1982

29-Apr 1 Design Engineering Conference and Show [ASME] Chicago, Illinois *(ASME Hqs.)*

APRIL 1982

14-16 Fatigue Conference & Exposition [SAE] Dearborn, MI *(SAE Hqs.)*

18-22 Gas Turbine Conference and Products Show [ASME] London, England *(ASME Hqs.)*

20-22 Mechanical Failures Prevention Group 35th Symposium [National Bureau of Standards] Gaithersburg, Maryland *(Dr. James G. Early, National Bureau of Standards, Building 223/Room A-113, Washington, DC 20234 - (301) 921-2976*

22-23 13th Annual Pittsburgh Conference on Modeling and Simulation [School of Engineering - Univ. of Pittsburgh] Pittsburgh, Pennsylvania *(William G. Vogt or Marlin H. Mickle, Modeling and Simulation Conference, 348 Benedum Engineering Hall, Univ. of Pittsburgh, Pittsburgh, PA 15261*

26-30 Acoustical Society of America, Spring Meeting [ASA] Chicago, Illinois *(ASA Hqs.)*

MAY 1982

12-14 Pan American Congress on Productivity [SAE] Mexico City *(SAE Hqs.)*

JUNE 1982

7-11 Passenger Car Meeting [SAE] Dearborn, MI *(SAE Hqs.)*

JULY 1982

13-15 'Environmental Engineering Today' Symposium and Exhibition [SEE] London, England *(SEE, Owles Hall, Buringford, Herefordshire, England)*

19-21 12th Intersociety Conference on Environmental Systems [SAE] San Diego, CA *(SAE Hqs.)*

AUGUST 1982

16-19 West Coast International Meeting [SAE] San Francisco, CA *(SAE Hqs.)*

SEPTEMBER 1982

13-16 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI *(SAE Hqs.)*

OCTOBER 1982

4-7 Symposium on Advances and Trends in Structural and Solid Mechanics [George Washington Univ. and NASA Langley Res. Ctr.] Washington, DC *(Prof. Ahmed K. Noor, Mail Stop 246, GWU-NASA Langley Res. Ctr., Hampton, VA 23665 - (804) 827-2897)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
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Lexington, MA 02173

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Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

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- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7, pp 97-106 (July 1975).
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7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

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